GLASS AND GLAZING

Comm... Al-61.

GLASS AND GLAZING

BY

D. M. J. DAVIDSON
A.R.T.C.

CROSBY LOCKWOOD & SON LTD
20 Tudor Street, London, E.C.4

FIRST PUBLISHED 1946

PRINTED IN GREAT BRITAIN BY
THE STANHOPE PRESS LTD.
ROCHESTER : : KENT

INTRODUCTION

GLASS, despite its antiquity, may rightfully be considered as a modern building-material. Its history can be traced to the first Egyptian dynasty (5,500 B.C.), yet developments in manufacturing processes and the production of new forms and surface finishes has kept it apace with modern building methods, and found ever increasing uses for it, either as a constructional or as a decorative medium.

During the war years the main concern has been to find a substitute for glass for window glazing, or to protect existing glazing from the effects of blast, and now that the time has come to rebuild or reglaze it will be found that some types and weights of glass have become obsolete and that new methods of glazing and fixing are being employed.

In this book an attempt has been made to provide in a compact form an up-to-date reference to the manufacture, uses and properties of all forms of glass used in building, as well as an account of modern glazing methods, including glass-concrete construction.

The author wishes to record his appreciation of the valuable assistance given to him by Messrs. Pilkington Bros., Limited, and Messrs. Chance Bros. & Co., Limited, and to acknowledge the permission given by them for the reproduction of graphs and photographs.

LIST OF PLATES

CONTENTS

CHAPTER I

GLASS—METHODS OF MANUFACTURE

Composition —Spinning —Blowing —Drawing —Casting —Rolling—Pressing

COMPOSITION. The main constituent of glass is silica, which is in itself an exceedingly durable and transparent material, but lacks workability. Other ingredients are added to produce a glass reasonable in cost and easily workable, but which retains the glass-like properties and resistance to atmospheric and chemical attack of the basic material.

The materials which may be added to produce a suitable glass are as follows:

Alkalis, such as sodium sulphate; to lower the melting temperature and viscosity of the glass.

Lime, in the form of chalk or limestone; to act as a fluxing agent and reduce susceptibility to weathering.

Borax; to impart resistance to chemical attack. Also gives glass with a low coefficient of expansion.

Alumina; improves workability and weathering properties.

Lead and Potash; produce the sparkling glass used for table ware (e.g. cut crystal). Potash also imparts infusibility and is used to produce heat-resisting glass.

Arsenic; renders glass colourless.

Manganese; produces whiteness.

Metallic oxides, such as magnesium, zinc, barium, etc.; act as fluxing agents and in some instances produce coloured glass.

Broken glass or cullet; added to the mix to 'lighten' it and assists in the vitrification of the mass by breaking up the bulk of sand and other ingredients.

It is for the glass maker to decide on the correct proportions of any of the above ingredients to produce the particular properties required. Different ingredients would be used for plate and sheet glass, bottle glass, optical glass, etc., but the general procedure is the same. The raw materials are measured and mechanically mixed before feeding into the furnace, generally a rectangular refractory lined structure which may be either gas or oil fired. The molten glass, which has a fusing temperature around 1,450°C., is then drawn off for the manufacture of glass by one or other of the following methods.

SPINNING. A blow pipe is dipped into the molten glass and a bulb of about 10 lbs. of glass is gathered on the end. This is blown into a globe-shaped mass with a nosed end, which is termed the Bullion or Bull's-eye. The globe is then transferred to a spinning rod or punty with a cup-shaped end, the cup enclosing the Bullion. The spinning rod is rotated in front of a furnace, causing the rim of the globe to expand until a flat circular disc is produced, having the Bullion as its centre. The glass cut from this disc is termed Crown glass and has a slightly curved brilliant fire polished surface. The Bullions, once looked upon as waste, are now much sought after as a decorative glass for door and window panels.

BLOWING. This was the original method of manufacturing sheet glass, but is now largely superseded by the flat drawn process. It is still used, however, in the production of hand-made glasses of the antique type. The whole operation is carried out by hand, and consists of gathering a quantity of molten glass at the end of a blow pipe which is then placed inside a block of wood, hollowed to the required diameter, and blown until a long elongated bulb is produced. The bulb is then reheated and blown to a larger diameter and further elongated by swinging it backwards and forwards over a sand pit. The ends are cut off, and the cylinder which

remains is cut down one side by a diamond. It is then transferred to a flattening kiln where, on softening, it falls flat on to the flattening table and is smoothed out by means of a wood float. The table may be of glass or stone and may be smooth or figured according to the surface finish required on the glass. A rough and speckly finish may be obtained by sprinkling sand on to the surface of the flattening table.

DRAWING. Drawn glass is produced by either a horizontal or vertical continuous process. The molten glass passes from the furnace into a drawing kiln, which is, in effect, a small extension to the furnace and is separated from it by a block of refractory material known as the 'shut-off' and a slab of similar material known as the 'tweel.' The glass, now in a viscous state, is drawn in a continuous ribbon through a slot in a refractory die or 'draw bar' and passes vertically through pairs of asbestos-covered rollers. The process is commenced by using an iron plate or bait which is lowered into the draw bar from the first two pairs of rollers. This is slowly lifted and draws behind it a ribbon of glass. Thereafter the process is continuous. The sheet hardens while suspended from the first set of rollers, the heat from the molten glass beneath giving a natural brilliant fire polish to both sides. The thickness of the glass remains uniform and is governed by the width of the die and spacing of the rollers. When the glass appears above the top pair of rollers it is cut into large plates which are removed for grading and cutting to convenient sizes.

CASTING. In its original form this process consisted of pouring molten glass on to a flat table around which were placed rectangular metal strips of the required thickness. The glass thus formed has a rough irregular surface and in its thicker substances, up to 1½ in. thick, is termed thick rough cast plate. In this form it is used for a number of applications which are described in a later chapter. Rough cast glass is also the basis for polished plate glass and rolled

glasses, but developments in the manufacture of these glasses have now made the casting table obsolete. The manufacture of rolled glass is dealt with separately, but it is opportune at this stage to include a brief description of the present day methods of producing polished plate glass.

'Casting' or 'forming' now consists of feeding molten glass through a pair of water-cooled steel casting rollers, producing a continuous ribbon which passes through a long horizontal tunnel or lehr. In this it is cooled gradually to atmospheric temperature in such a manner as to minimise the internal stresses developed on cooling and to prevent warping. When cooled, it is cut into sheets and passed to the grinding and polishing table. This is a continuous moving table on which the cast sheets are bedded down with plaster of paris. The surface of the glass is ground smooth by a series of revolving cast iron discs. These are fed by sand and water, commencing with coarse sand on the first pair of discs and finer sand on each succeeding pair, until a dull, smooth finish is obtained. Polishing is carried out in a similar manner with felt pads on the discs, using rouge and water as an abrasive. When one surface has been polished, the sheet is turned over and the other side treated in a similar manner. The latest development in the manufacture of polished plate glass is the introduction of a continuous machine in which both sides of the glass are polished simultaneously. In this process the continuous ribbon formed by casting, after leaving the lehr, is fed directly to the grinding and polishing machine. Glass produced in this manner is known as Twin Plate, and is free from any distortion or wave.

ROLLING. Most of the rolled glasses of to-day are produced by the continuous rolled process. In this, molten glass is directed on to a pair of metal rollers through a specially designed refractory spout. One or both of the rollers are embossed, according to the pattern of glass being produced. In most cases one surface, generally the upper, is smooth, and the other patterned. The glass emerges from the rollers

in a continuous ribbon, which passes through a lehr in which it is gradually cooled to atmospheric temperature. On leaving the lehr, the glass is cut into sheets of a convenient size for handling and storage. In the manufacture of wired rolled glass the wire mesh is inserted during the process of rolling.

In the older intermittent process molten glass is cast on to a table and rolled, producing individual slabs or sheets.

PRESSING. Glass may be pressed into steel moulds to form a variety of commodities, such as roof lights, pavement lights, lenses, moulded architraves and panels and glass bricks. These products are described fully in the succeeding chapters.

The pressing machine is usually circular, having a number of similar cast-iron moulds spaced around its circumference.

The molten glass is fed to the mould in ribbon form, the required amount being cut off by automatically-controlled scissors. The machine is made to rotate a fraction of a turn, bringing the next mould into line to receive the next offcut of molten glass. Meanwhile, the first mould has moved under a press which stamps the glass to the required shape. Successive rotations of the machine enable edge and surface treatments to be given where these are necessary, the glass pressing being finally ejected and passed by conveyor to the cooling lehr. Glass bottles are produced in a similar manner, except that the glass is blown to the shape of the mould by compressed air instead of stamping.

CHAPTER II

WINDOW AND DECORATIVE GLASSES

Crown Glass—Blown Glass—Drawn Sheet Glass—Rough Cast Plate—Polished Plate—Rolled Glass

CROWN GLASS. This can always be recognised by its brilliant lustre and slightly curved surface. It is produced by spinning, and the centres of the discs are known as Crown Bullions or Bull's-Eyes. The maximum size available is 14 in. by 12 in., but the more usual size is 12 in. by 10 in. Crown Bullions may be obtained in sizes up to 20 in. by 16 in.

Crown glass is used in the replacement of old glazing and for new work such as bow-fronted windows, glass doors and screens, where a period reproduction finish is desired. It should always be fixed with the convex side outwards. Where Crown Bullions are used, these should be sparingly interspersed with plain Crown Glass to give the desired effect. Although very little Crown Glass is now produced there is still a demand for Bullions, and these are often spun separately and used in conjunction with ordinary sheet or plate glass.

BLOWN GLASS. This term covers the decorative sheet glasses produced by the earlier process of manufacturing clear sheet glass. The irregular and brilliantly fire-polished surface produced by blowing is much sought after for decorative glazing, leaded lights, etc. Only relatively small sheets are produced, the standard being 24 in. by 15 in. approximately. The usual thickness is $\frac{3}{16}$ in. A variety of textures are available, of which the following are the best known:

Cathedral Sheet. This is similar in appearance to Rolled Cathedral, but has the imperfections of old glass, such as

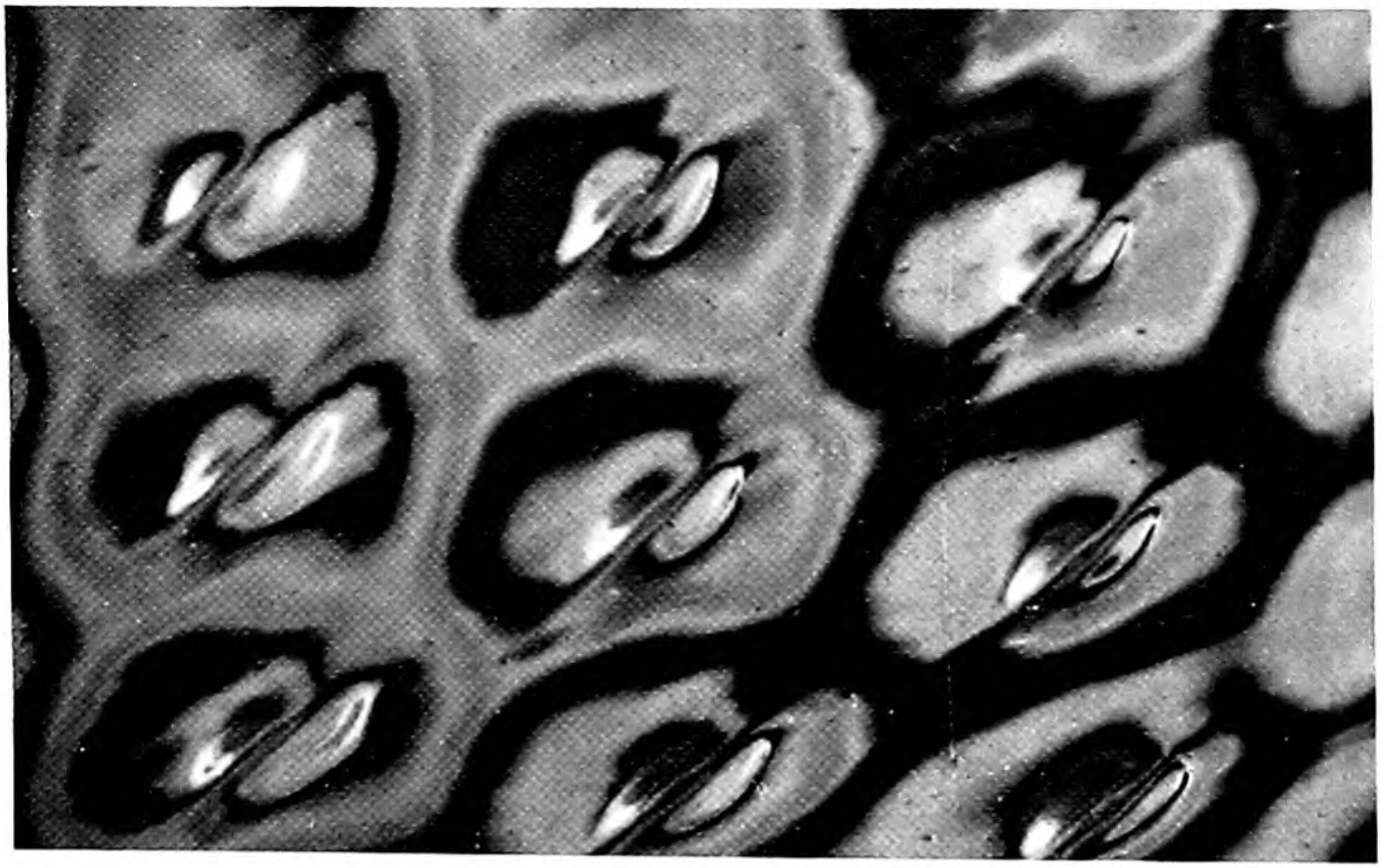


Plate No. 1. Hand-made Antique Venetian.

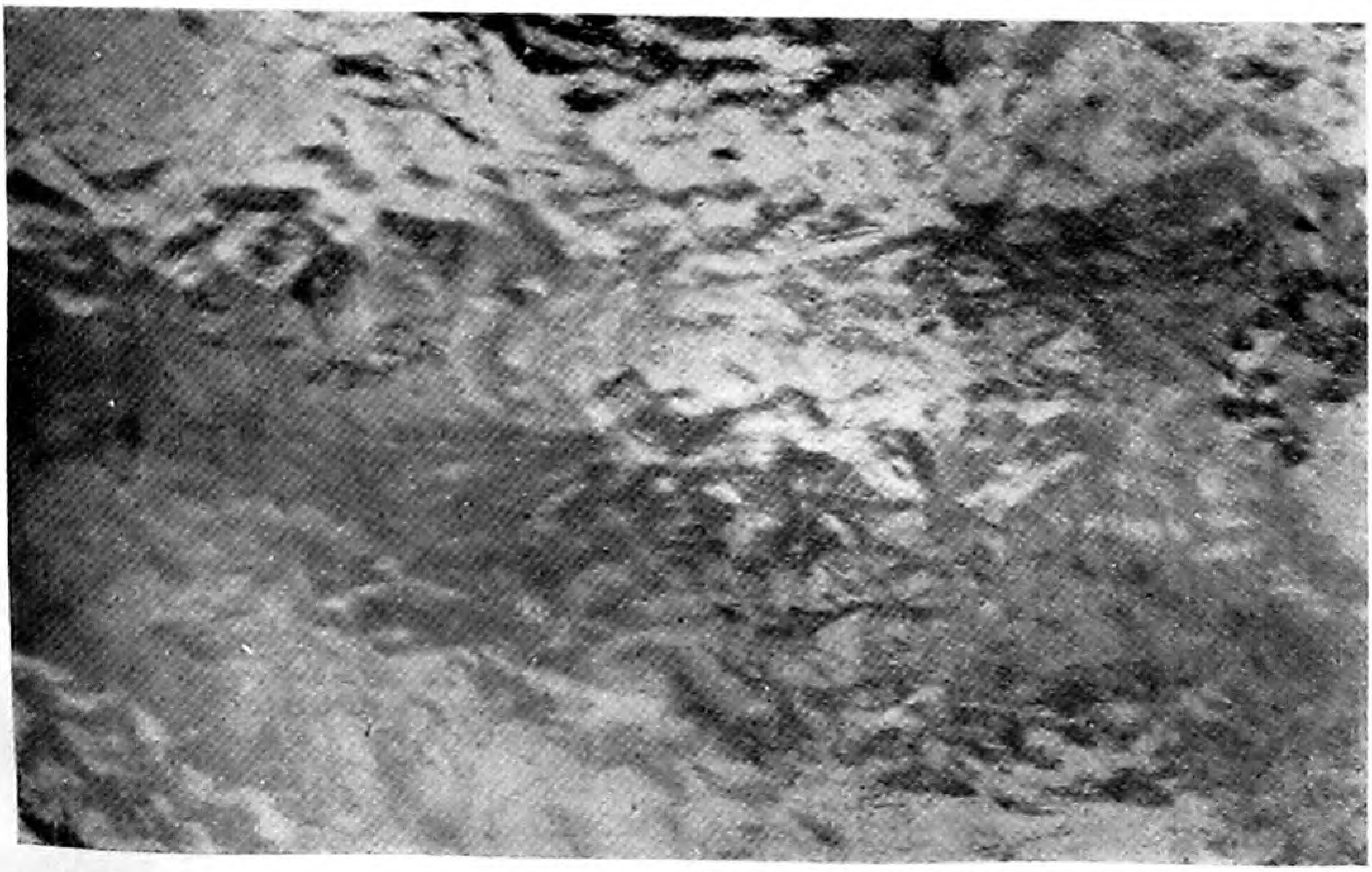


Plate No. 2. Double Rolled Cathedral.

Plate No. 3. Clouded Cathedral.

Plate No. 4. Flemish.

bubbles, streaks and irregular surface. It is obtainable in an almost unlimited range of delicate tints.

Specky Sheet. This resembles Cathedral Sheet, but the specks or bubbles are multiplied and the imperfections increased. It is made in rather stronger tints than Cathedral Sheet.

Sanded Sheet. The pimply roughness of this glass is produced by throwing sand grains on the flattening table. These become fused into the surface of the glass producing a slight obscuration with small pin points of light.

Muffled Sheet. This has a rippled or dappled surface, but of a less mechanical pattern and greater brilliancy than rolled sheet. It gives a distorted vista and is suitable for leaded lights or screens where some privacy is required.

Reamy Antique. This is a semi-obscure glass, both sides having a wavy texture and a brilliant fire polish. It has a high light transmission factor and is easily cleaned. It is used mainly for church windows and other decorative glazing, but is also suitable for windows with an unattractive view. It is available in pure white, pale and streaky tints, and in full colours.

Norman Slabs. These are made in small rectangular panes with one side slightly convex. They have an irregular ripply surface, and although quite obscure have a high light transmission factor. The principal sizes are 13 in. by 10 in., 11 in. by 8 in., 9 in. by 6 in. and 7 in. by 5 in. The thickness is approximately $\frac{1}{8}$ in. at edges. They are made in crystal, pale tints, streaky tints and in full colours.

Flashed Opal. This is a blown sheet glass, during the manufacture of which a thin layer or flash of a white opal glass is imposed upon a clear or tinted base, providing a completely obscure glass. The usual weights are 15 to 18 oz. and 21 to 24 oz. The shades available are blue (two shades); green; pink and yellow (two shades). These glasses are used mainly for illumination purposes, such as signs, light fittings, etc. A colour flash is also made on

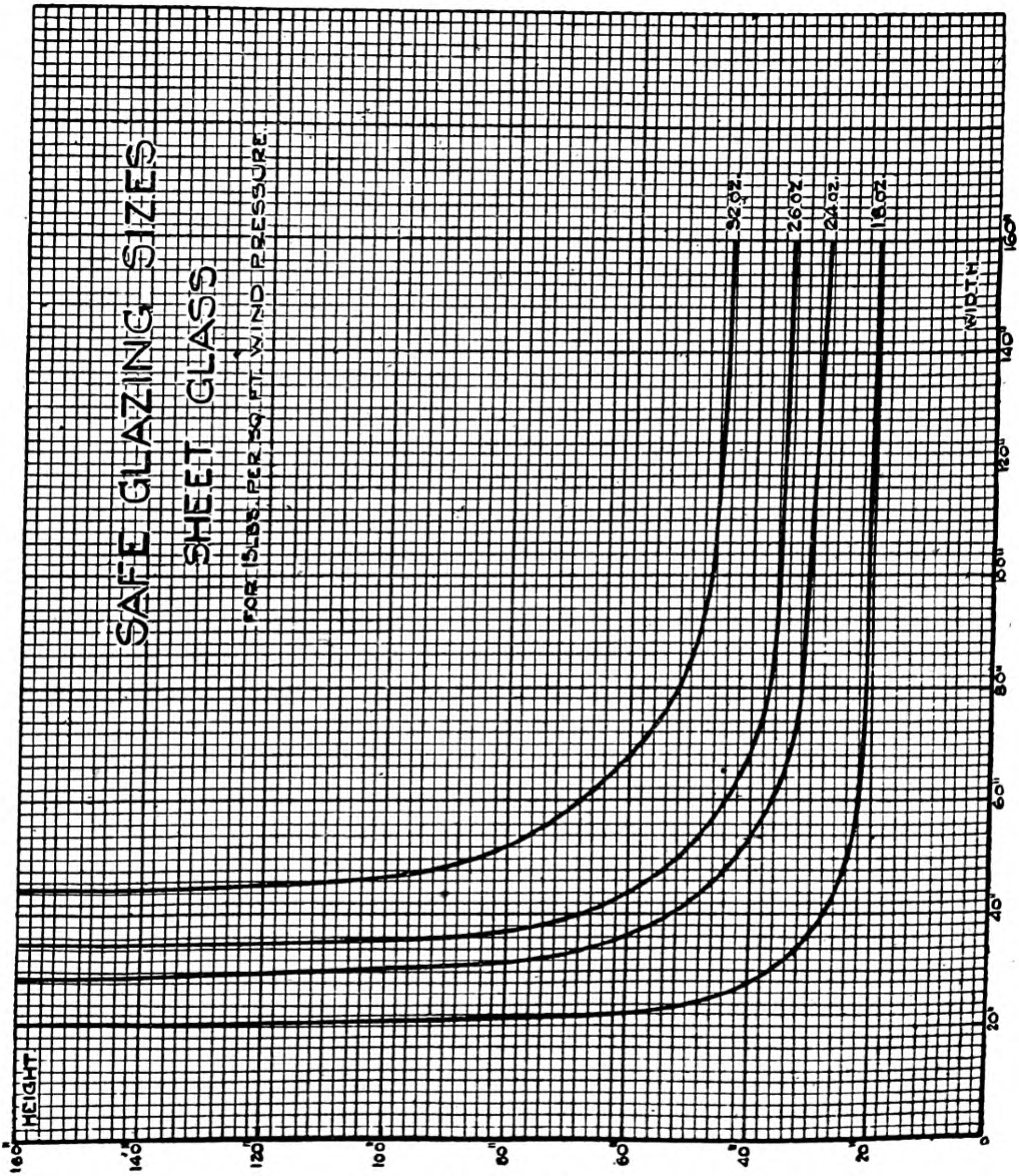

SAFE GLAZING SIZES
SHEET GLASS
FOR 15LBS. PER SQ. FT. WIND PRESSURE.
32 OZ.
26 OZ.
24 OZ.
16 OZ.
HEIGHT
WIDTH
0
20"
40"
60"
80"
100"
120"
140"
160"

FIG. No. 1.

pot opal. This is in 15 oz. substance and is made in a variety of colours. It is used mainly for signs.

DRAWN SHEET GLASS. This is a glass of almost true flatness and brilliant lustre. It is uniform in thickness and is free from the irregularities and other defects of Blown Sheet Glass. In its lighter substances it is generally known as Flat Drawn Sheet Glass, and Heavy Drawn in its thicker substances. In the past there have been some slight variations in the descriptions of the standard qualities of Flat Drawn Sheet Glass, but these have now been defined in the British Standards Institution Specification No. 952-1941; British Standards for Glass for Glazing. The maximum permissible sizes of Drawn Sheet Glass are governed, not so much by limitations due to method of manufacture as to ability to withstand normal wind pressures when fixed. The curves shown in Fig. No. 1 indicate the maximum glazing sizes for each standard thickness for a wind pressure not exceeding 15 lbs. per square foot. The three main qualities are:

Ordinary Glazing Quality (O.Q. or B.). Suitable for general glazing purposes.

Selected Glazing Quality (S.Q. or A.). Suitable for glazing work in public buildings, offices, etc., requiring selected glass above Ordinary Glazing Quality.

Special Selected Quality (S.S.Q. or A.A.). For pictures, cabinet and other work where a superfine glass is required. It is often used for positions where a less expensive glass than Polished Plate is required.

There is also a horticultural quality made only in 24 oz. substance which is only suitable for greenhouses, garden frames, and cloches.

The standard weights and thicknesses are:

$$\left.\begin{array}{lll} \text{18 oz.: approximately} & \tfrac{1}{12} \text{ in.} \\ \text{24 ,,} \quad\quad\quad \text{,,} & \tfrac{1}{10} \text{ ,,} \end{array}\right\} \text{For general glazing work.}$$

26 oz.: approximately $\frac{1}{8}$ in.	Used for glazing in larger sizes and exposed positions.
32 ,, ,, $\frac{5}{32}$,,	

Thick Drawn or Heavy Sheet of foreign manufacture, in $\frac{3}{16}$ in. and $\frac{1}{4}$ in. thicknesses, is sometimes used for shelves, table tops, etc., where a cheaper and poorer quality glass than Polished Plate can be accepted.

ROUGH CAST PLATE. This is primarily made for grinding and polishing in order to produce Polished Plate Glass, but may also be used constructionally or decoratively. Constructionally it is used for pavement lights, stall boards, roof lights, etc., and decoratively for table tops, counter tops, bath panels, pilasters, etc.

It may be used exactly as manufactured with one surface sandblasted or silvered. Certain defects, such as manufacturing lines, rust marks, variation of pattern and scratches are to be expected and should be borne in mind when using the glass decoratively.

Thicknesses range from $\frac{1}{2}$ in. to $1\frac{1}{2}$ in. The choice of thickness is governed by the size of glass, method of fixing, weight to be carried, etc.

The following types are available:

British

$\frac{1}{2}$ in.:

(*a*) Made in Rolled metal, which has a double rolled surface as in $\frac{1}{4}$ in. thickness.

(*b*) Made in Plate metal as in $\frac{5}{8}$ in. and thicker substances.

$\frac{1}{2}$ in., and $\frac{5}{8}$ in. to $1\frac{1}{2}$ in.:

(*a*) Both surfaces wavy or patterned in varying degrees according to age of roller used. No guarantee of regularity.

(*b*) One surface wavy, one surface ribbed; this occurs when made by a slightly different process.

The manufacturers make the following observations:

(1) None of the above types can be taken as standard,

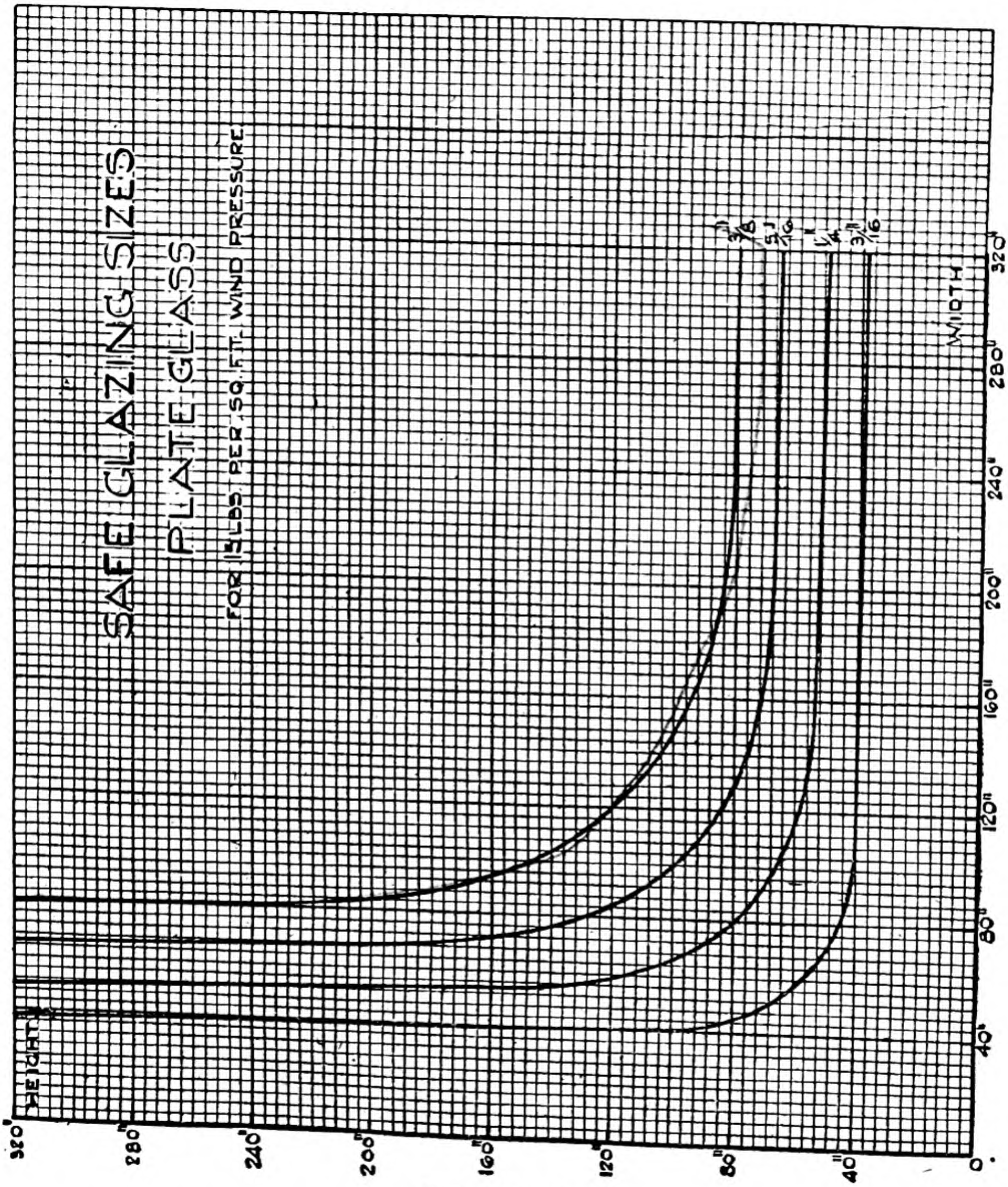


Fig. No. 2.

acc no 7090

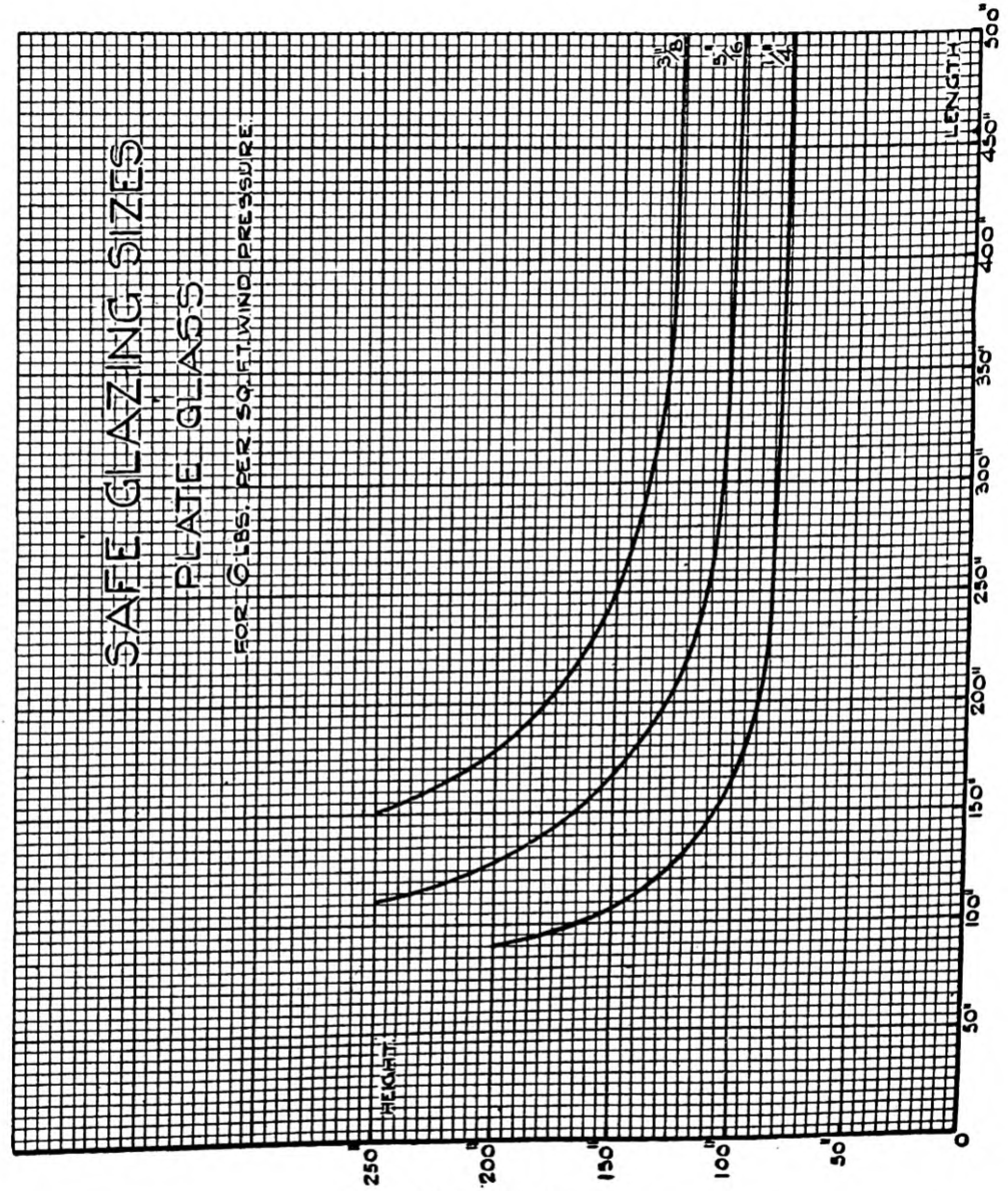

SAFE GLAZING SIZES
PLATE GLASS
FOR 6 LBS. PER SQ. FT. WIND PRESSURE
3/8"
5/16"
1/4"
LENGTH
HEIGHT
0
50"
100"
150"
200"
250"
300"
350"
400"
450"
500"
50"
100"
150"
200"
250"

FIG. No. 3.

and unless the order is specially negotiated any of the above may be supplied.

(2) The manufacturers are willing to see whether samples can be matched from existing stocks, but cannot give any guarantee of success.

(3) Orders should always state whether one surface is to be sandblasted or not.

Foreign:

(*a*) Standard. Smooth one surface, rough sanded on the other.

(*b*) Also obtainable. Smooth one surface, ribbed the other.

(*c*) Coloured. The manufacturers will make this specially if an order can be placed for a minimum quantity of 250-400 ft., according to thickness. Stocks are sometimes available in London of "Rosetint" Thick Rough Cast in $\frac{5}{8}$ in. and $\frac{3}{4}$ in.

POLISHED PLATE GLASS. As with Drawn Sheet Glass, the limiting factor for maximum sizes is the ability to withstand wind pressures. The curves shown in Figures Nos. 2 and 3 indicate the maximum glazing size for thicknesses from $\frac{3}{16}$ in. up to $\frac{3}{8}$ in. The standard qualities of Polished Plate Glass are defined in British Standards Institution Specification No. 952-1941; British Standards for Glass for Glazing. These are:

Glazing for Glazing (G.G.). For ordinary glazing such as windows, shop fronts, show cases, shelves, table tops, etc.

Selected Glazing Quality (S.G.). For selected glazing; standard for mirrors.

Silvering Quality (S.Q.). A superfine quality used for high grade mirrors, photographic work and other purposes. Other qualities are:

Twin Plate and Planimetrie, which are used for large mirrors where a true reflection is important, e.g. where opposite walls are covered with mirrored glass to give

the appearance of increased space.

Thicknesses range from $\frac{1}{8}$ in. up to $1\frac{1}{2}$ in.

$\frac{1}{8}$ in., $\frac{3}{16}$ in. Used in motor and photographic work and sometimes specified for glazing in small squares in houses, flats, offices, etc., but is more costly than $\frac{1}{4}$ in.

$\frac{1}{4}$ in. This is the standard thickness; used for windows, shop fronts, show cases, table tops, dressing table and window sill covers, mirrors, shelves, etc. There is a commercial variation in thickness from $\frac{7}{32}$ in. to $\frac{9}{32}$ in. It weighs approximately $3\frac{1}{2}$ lbs. per square foot.

$\frac{5}{16}$ in. to $\frac{3}{8}$ in. Used for specially large shop fronts, counter tops and shelves carrying weight.

$\frac{1}{2}$ in. to $1\frac{1}{2}$ in. Used for ships' portholes, aquarium tanks, gauge glasses and other special purposes.

Coloured Plate Glass

Polished Plate Glass is also manufactured in the following colours: blue, green, amethyst, pink, amber (or yellow), neutral (or grey). There are also standard shades of most of these colours, of which the following tints are in most general use:

Standard blue, pale blue (a very faint tint), medium green, medium amber, dark neutral (mostly used in clear form for ambulance work, occasionally for black mirrors), light neutral, rosetint (or pink), amethyst.

It is difficult to obtain exact uniformity of colour and in large schemes a sample should be agreed. Thicknesses are generally from $\frac{3}{16}$ in. to $\frac{1}{4}$ in.

Coloured Plate Glass is used mainly for mirrors. The warmer tints, such as rosetint, suntint, light neutral and heather as complete mirrors and the other darker shades as surrounds. Decorative effects may be obtained by acid engraving, sandblasting, or brilliant cutting and then mirroring. Coloured Plate is also used in clear form for decorative glazing, shelves and table tops.

ROLLED GLASSES. The term 'Rolled Glass' covers all the Roofing Glasses, either plain or wired, and the Cathedral Figure Rolled Glasses, produced by either the intermittent or continuous rolled process.

ROOFING GLASSES

Rough Cast or Double Rolled Rough Cast. This glass has a slightly rough uneven texture on both surfaces. It is a translucent glass with medium obscuration, used for glazing of skylights and roofing where the extra protection of wired glass is unnecessary. It is also used for factory windows.

The maximum standard sizes are:

120 in. by 46 in. or 130 in. by 26 in. for $\frac{3}{16}$ in. thickness, and 120 in. by 46 in. or 144 in. by 26 in. for $\frac{1}{4}$ in. thickness.

Plain Rolled or Hartley's Rolled (Ribbed). One surface is impressed with parallel ribs (19 to 1 inch) providing considerable obscuration. Maximum standard sizes are as for Rough Cast with the addition of 120 in. by 42 in. in $\frac{1}{8}$ in. thickness. It is used for roof glazing, skylights, and factory windows where an obscured glass is required.

Wired Rolled Glasses. These are dealt with under Wired Glass in Chapter III.

CATHEDRAL AND FIGURED ROLLED. These may be classified according to type of pattern. They are used for obscured glazing in office screens and partitions, doors, leaded lights, bathrooms, kitchens, and for lighting and decorative effects.

The following list gives the principal varieties under each of four categories:

(*a*) Irregular but smooth patterns: Clear, Plain, Double Rolled, Clouded, Rimpled, Waterwite, Stippled, Mottled and Rough Cathedrals.

(*b*) Regular and imprinted patterns: Hammered Cathedral,

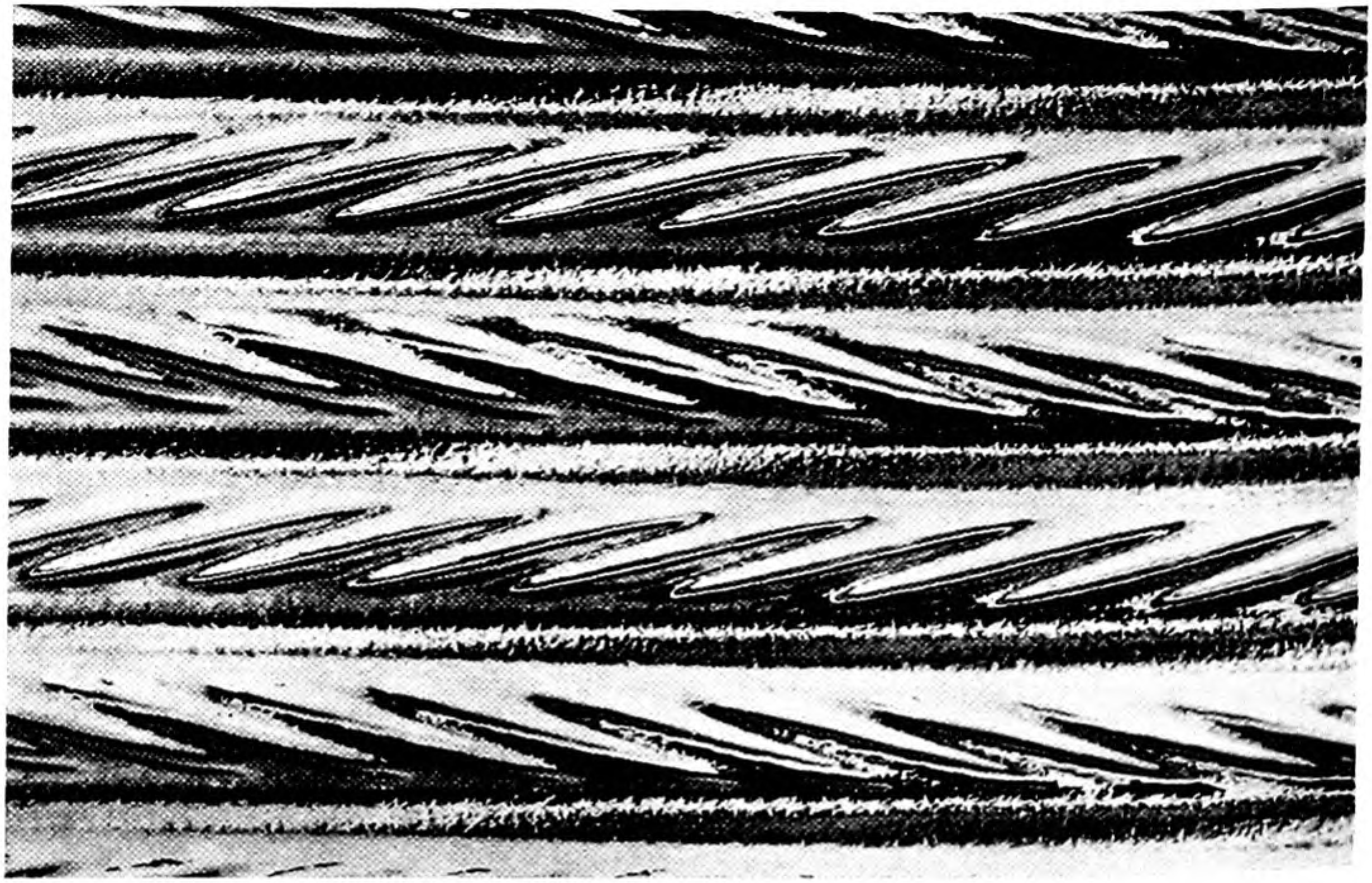


PLATE NO. 7. FEATHERED WASHBOARD.

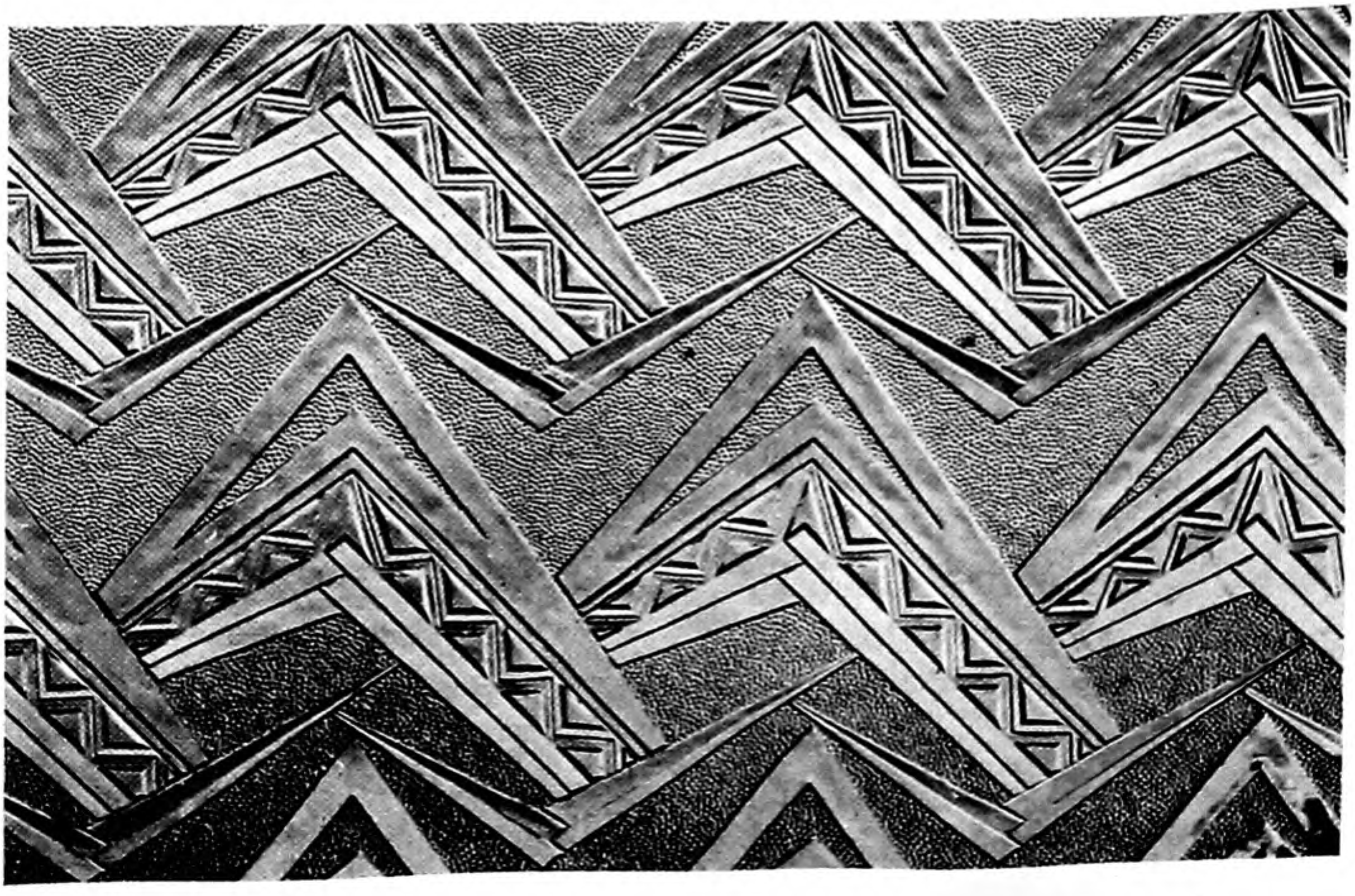


PLATE NO. 8. BLAZONED GLASS.

CHAPTER III

SPECIAL PURPOSE GLASSES

Wired Glass—'Armourplate' and Toughened Glass—'Thermolux'—'Vita' Glass—Heat Resisting Glass—and other special glasses

Wired Glass. The principal use for Wired Glass is in roof glazing, lantern lights, lay lights, etc., where, in the event of breakage, splinters are prevented from falling, thus affording a safeguard against injury. It also affords protection against burglary and the spread of fire. It is accepted by the London County Council as a fire resisting material, provided that no pane is greater than 24 in. in either direction. In this connection it can be used for the glazing of doors and fanlights of flats, offices, etc., leading to a common landing or corridor in the building.

There are two types of reinforcement: (1) hexagonal mesh, about $\frac{7}{8}$ in. across; and (2) 'Georgian' (square) mesh, about $\frac{1}{2}$ in. square. The latter is of smaller diameter and is electrically welded. It is considered to have a better appearance than hexagonal mesh, but is more costly. Wired Glass is obtainable in the following forms:

Wired Polished Plate. This is available in either hexagonal or 'Georgian' mesh in $\frac{1}{4}$ in. thickness and in sizes up to 110 in. by 36 in. It is used for windows, partitioned offices, counting houses, door panels and other situations where appearance is of first importance and a clear view is required.

Wired Rolled Rough Cast. This is obtainable in both hexagonal and 'Georgian' mesh in $\frac{1}{4}$ in. thickness and in sizes up to 120/140 in. by 36/40 in. It is used for factory roofs, sky-lights, etc.

Wired Rolled (Ribbed). This is obtainable only in hexagonal mesh, in $\frac{1}{4}$ in. thickness and in sizes up to

120/140 in. by 36/40 in. It is used mainly for factory roofs.

Wired Patterned Glass. For positions where a wired obscured glass is required the following wired pattern glasses are available: Wired Arctic, Wired Pattern G, Wired Dewdrop and Wired Amber Cast. These all have hexagonal mesh and are in $\frac{1}{4}$ in. thickness in sizes up to 90 in. by 36 in.

Wired 'Vita' Glass. 'Vita' Glass, described later in this chapter, is also available in wired rough cast form. It has 'Georgian' mesh and is in $\frac{3}{16}$ in. thickness; maximum sizes 108 in. by 24 in.

'ARMOURPLATE' AND TOUGHENED GLASS. 'Armourplate' Glass is made by subjecting ordinary Polished Plate Glass to a patent toughening process, the effect of which is to greatly increase its mechanical strength and resistance to large and sudden changes of temperature. 'Armourplate' will withstand hard knocks and a certain amount of twisting and bending. When fractured it disintegrates into small rounded pieces unlikely to cause serious injury.

The toughening process consists of heating the glass in an electric furnace until the softening point is reached, followed by a sudden cooling by air directed to both sides of the glass. The outer surfaces solidify, while the core remains hot and soft. As cooling continues the outer layers are drawn into compression, so increasing the mechanical and heat resisting properties of the glass.

The full effect of this process is only obtained when clear Polished Plate Glass without any surface treatment is used, the resulting product being given the trade name 'Armourplate,' which is indelibly marked on each piece of glass. Other glasses may be subjected to the same process, also Polished Plate which has been embossed, brilliant cut or drilled, and these are then referred to as 'toughened glass.'

Any surface treatment, drilling, bevelling, etc., must be carried out before toughening, as no further work can be

done after treatment. Where holes have to be drilled, these should not be near the edge. Bevelling can only be supplied up to $\frac{1}{2}$ in. wide and $\frac{1}{8}$ in. deep. Care must be taken to prevent damage to the edges of both 'Armourplate' and 'toughened' glass, as these edges are no stronger than 'ordinary' glass.

Glass lenses may also be toughened, and are described in Chapter VIII.

'THERMOLUX' GLASS. This is a light-diffusing, heat-insulating glass consisting of two sheets of clear glass with an interlayer of spun glass fibres. These fibres are approximately 0.0005 inches diameter and for general glazing are white, but may be tinted for use in decorative panels, lighting effects and screens. The colours available are pale and dark amber, pale and dark blue, pink, green and marbled effects of these colours. The interlayers are variable in density according to requirements. The standard thicknesses are:

$\frac{1}{25}$ in. (1 mm.): for all upright glazing, except where privacy is important.

$\frac{1}{16}$ in. (1.5 mm.): for all roof glazing exposed to the sun; for upright glazing (1) where the sun is often hot or the light intense, and (2) where privacy is essential.

$\frac{1}{16}$ in. full (2 mm.): for windows in hot climates.

$\frac{1}{10}$ in. (2.5 mm.): for roofs in hot climates.

$\frac{1}{8}$ in. (3 mm.): for particularly heavy insulation against radiant heat.

The edges of each panel are hermetically sealed with an impervious adhesive which prevents 'breathing' and consequent loss of thermal and light-transmitting properties.

The maximum sizes for windows are approximately 9 ft. long by 6 ft. wide, and for roofs and lay lights approximately 10 ft. long by 2 ft. 6 in. wide.

'Thermolux' Glass gives an even diffusion of colourless light into a room and maintains true colour values. It also insulates against the sun's heat and conserves indoor warmth.

It is used for the glazing of windows, roofs and lay lights

Type	Maximum Sizes			Characteristics and Uses
	Thickness	Length	Width	
'Armourplate.' Clear Polished Plate.	$\frac{3}{16}$ in.	51 in.	25 in.	Resistance to impact 7 times that of ordinary Plate Glass. Resistance to pressure 4 times that of ordinary Plate Glass. Will withstand temperatures up to 300°C. on one surface with other surface exposed to atmosphere. Complies with B.S.I. for Fire Resisting Materials, Grade D, i.e. it will provide protection against the spread of fire for at least 1 hour. Principal uses: Trolley and table tops, screens, shelves, frameless entrance doors, gas and electrical cooker doors, windows for mental hospitals, fire screens and industrial applications.
	$\frac{1}{4}$ in.	70 in.	52 in.	
	$\frac{5}{16}$ in./$\frac{3}{8}$ in.	82 in.	70 in.	
	$\frac{1}{2}$ in.	82 in.	70 in.	
	$\frac{5}{8}$ in.	82 in.	52 in.	
	$\frac{3}{4}$ in. $\frac{7}{8}$ in. 1 in. $1\frac{1}{4}$ in.	Can be supplied in sizes up to 8 sq. ft. Larger sizes and thicknesses should be submitted to manufacturers for consideration.		
Toughened Thin Plate Glass.	2.6/3.2 mm.	24 in.	18 in.	Twice as strong as ordinary glass of same thickness. Will withstand temperatures up to 200°C. if uniformly applied. Used where a lighter substance than $\frac{3}{16}$ in. or $\frac{1}{4}$ in. plate is required, such as for scientific instruments.
	3.2/4.0 mm.	36 in.	24 in.	
Toughened Tinted Polished Plate Glass. In Steel Blue, Standard Blue, Pale Blue, Amber, Pink, Dark Green.	$\frac{1}{4}$ in.	70 in.	30 in.	Used for underwater lighting, floodlights, fire screens.
Amber also in	$\frac{3}{16}$ in.	51 in.	25 in.	

Type	Maximum Sizes			Characteristics and Uses
	Thickness	Length	Widte	
Toughened Black Glass.	$\frac{5}{16}$ in. $\frac{3}{8}$ in. $\frac{1}{2}$ in.	82 in. and in 110 in.	70 in. strips 9 to18 in.	Resists sudden changes in temperature. Used for exterior work, shop fronts, table and sideboard tops.
	$\frac{3}{4}$ in.	Up to 8 ft. super.		
Toughened Rough Cast Rolled.	$\frac{1}{4}$ in. $\frac{3}{8}$ in.	70 in. 70 in.	30 in. 52 in.	Used for police cell windows; windows in mental hospitals.
Toughened Sheet Glass.	18 oz. 14 & 26 oz. 32 oz.	14 in. 24 in. 36 in.	10 in. 18 in. 24 in.	Twice as strong as ordinary sheet glass. Used for instruments and special glazing.
Toughened Figured and Cathedral Glasses. White and tinted in certain standard patterns.	$\frac{1}{8}$ in. $\frac{1}{4}$ in.	24 in.	18 in.	Twice as strong as ordinary sheet glass. Will withstand temperature up to 150°C. when heated uniformly, even when sprayed with cold water. Used for lighting effects, flood-lighting and other uses where strength and heat - resisting properties are required.
Toughened Stippolite Silenium Glass. In Peacock Blue, Olive, Emerald, Flame, Orange.	$\frac{1}{8}$ in.	24 in.	18 in.	
Toughened Clear Glass Flashed Opal. Amber (Flashed), Signal Green (Pot), Amber (Pot), Opal (Flashed), Dark Blue (Pot), Green (Pot), Ruby (Flashed).	3 mm.	24 in.	18 in.	

in factories, workshops, stores, showrooms, shops, hospitals, schools, studios and public buildings.

In white or colours it is used to give lighting effects with both natural and artificial lighting.

'VITA' GLASS. Ordinary window glass, whether plate or sheet, contains certain impurities which not only reduce its light transmission factor, but prevent the passage of ultra violet or 'health rays' of the sun. 'Vita' Glass is a glass of high purity which has the property of permanently admitting the passage of these rays. It is therefore valuable for glazing in hospitals, sanatoria, schools, nurseries and sun lounges. Windows glazed with 'Vita' Glass need not face south, as light diffused by blue sky and white clouds is also rich in ultra violet rays.

'Vita' Glass is available in the following types:

	Thickness (or weight)	*Maximum Sizes* Length	Width
Clear Sheet	18/20 oz.	48 in.	24 in.
Clear Plate	$\frac{5}{32}$ in.	96 in.	40 in.
Semi-Transparent	$\frac{1}{8}$ in.	60 in.	6/18 in.
Cathedral	$\frac{3}{16}$ in.	84 in.	20 in.
'Georgian' Wired Cast	$\frac{3}{16}$ in.	60/84 in.	20/30 in.

HEAT RESISTING GLASS. The heat resisting properties of 'Armourplate' and 'Toughened' Glass have already been described. For special industrial uses boro-silicate glass is produced in the form of precision bore tubing and pressings.

PRISMATIC GLASS. This glass is used for basements and other windows shut off from direct illumination. It is a translucent rolled glass with one surface smooth and the other having parallel ribs in the form of prisms which cause the light passing through the glass to be reflected. The angle of reflection varies according to the shape of the prisms, and three standard types are produced:

Prismatic Angle No. 1: for use when angle of light is between 15° and 35°.

Prismatic Angle No. 2: for use when angle of light is between 35° and 45°.

Prismatic Angle No. 3: for use when angle of light is greater than 45°.

These are $\frac{1}{4}$ in. thick, weighing approximately 3 lbs. per square foot and are made in sizes up to 100 in. wide by 60 in. high with prisms running horizontally and on the inside of the window.

MAXIMUM DAYLIGHT GLASS. This is also a prismatic glass with lenses on the outside and ribs on the inside. The outer lenses or flutes are at right-angles to the ribs on the inside and give additional lateral diffusion.

It is made in $\frac{3}{16}$ in. to $\frac{1}{4}$ in. thickness, weighing approximately $2\frac{1}{4}$ to $2\frac{1}{2}$ lbs. per square foot, and in two angles:

Angle A: for use when the angle of light is not more than 25°-30°.

Angle BD: for use when the angle of light exceeds 40°.

The maximum sizes are 100 in. by 40 in. with prisms running either the length or breadth of the sheet.

It is used for the same purposes as prismatic glass.

NON-ACTINIC OR TROPICAL GLASS. Just as the elimination of certain impurities in ordinary glass will increase its ability to pass ultra violet rays, so will the addition of such 'impurities' decrease its transmission factor of both heat rays and ultra violet rays. Non-Actinic or Tropical Glass contains those added ingredients, is opaque to ultra violet light and is used to eliminate glare and exclude the sun's heat. It is a rolled glass of similar appearance to ordinary tinted Double Rolled Cathedral Glass and has a soft greenish tint.

It is made in $\frac{1}{8}$ in., $\frac{3}{16}$ in. and $\frac{1}{4}$ in. thicknesses, and in

sizes up to 90/110 in. by 24/42 in. It is used for positions similar to those mentioned under Calorex Glass.

CALOREX GLASS.—This is a heat absorbing glass of a slightly greenish tinge. It will absorb (or exclude) 80% of the sun's heat while transmitting 60% of its light. It is used for Factories, Warehouses, Food Stores, Larders, Summer Houses and Verandah roofs and other instances where heat is to be excluded. It is used extensively in tropical countries. The following types are available:

			Maximum Sizes	
		(Thickness (or weights)	Length	Width
Rough Cast	..	$\frac{1}{8}$ in.	96 in.	40 in.
,, ,,	..	$\frac{1}{4}$ in.	60/90 in.	24/36 in.
Glistre ..	..	$\frac{1}{8}$ in.	96 in.	40 in.
Polished Plate	..	$\frac{1}{4}$ in.	60 in.	36 in.
Sheet ..	..	21 oz.	45 in.	30/36 in.
		32 oz.	40 in.	32 in.

ANTI-FLY GLASS. This is a special amber tinted Cathedral Glass, the colour of which acts as a deterrent to flies.

It is used for larders, food stores, butchers' shops, etc. It is made in $\frac{1}{8}$ in. thickness and sizes up to 90/100 in. by 36/42 in.

SPECTRALITE GLASS. This is a Plate Glass with a special pinkish tinge, which is used for display cabinets, etc., to correct the greenish tinge produced with ordinary clear Plate Glass. Articles of food, such as biscuits, are enhanced in appearance when viewed through this type of glass.

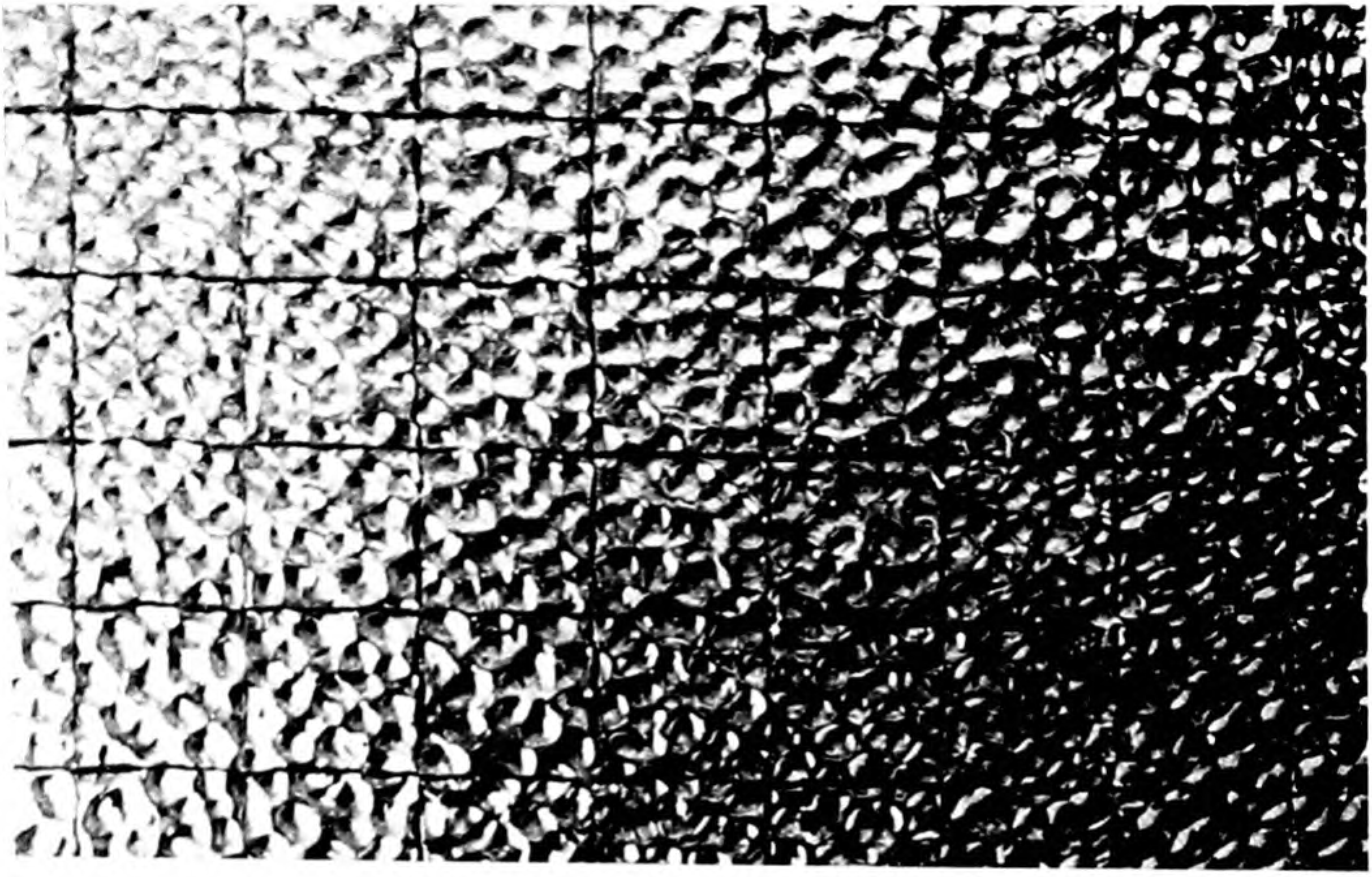


Plate No. 9. Georgian Wired Cast.

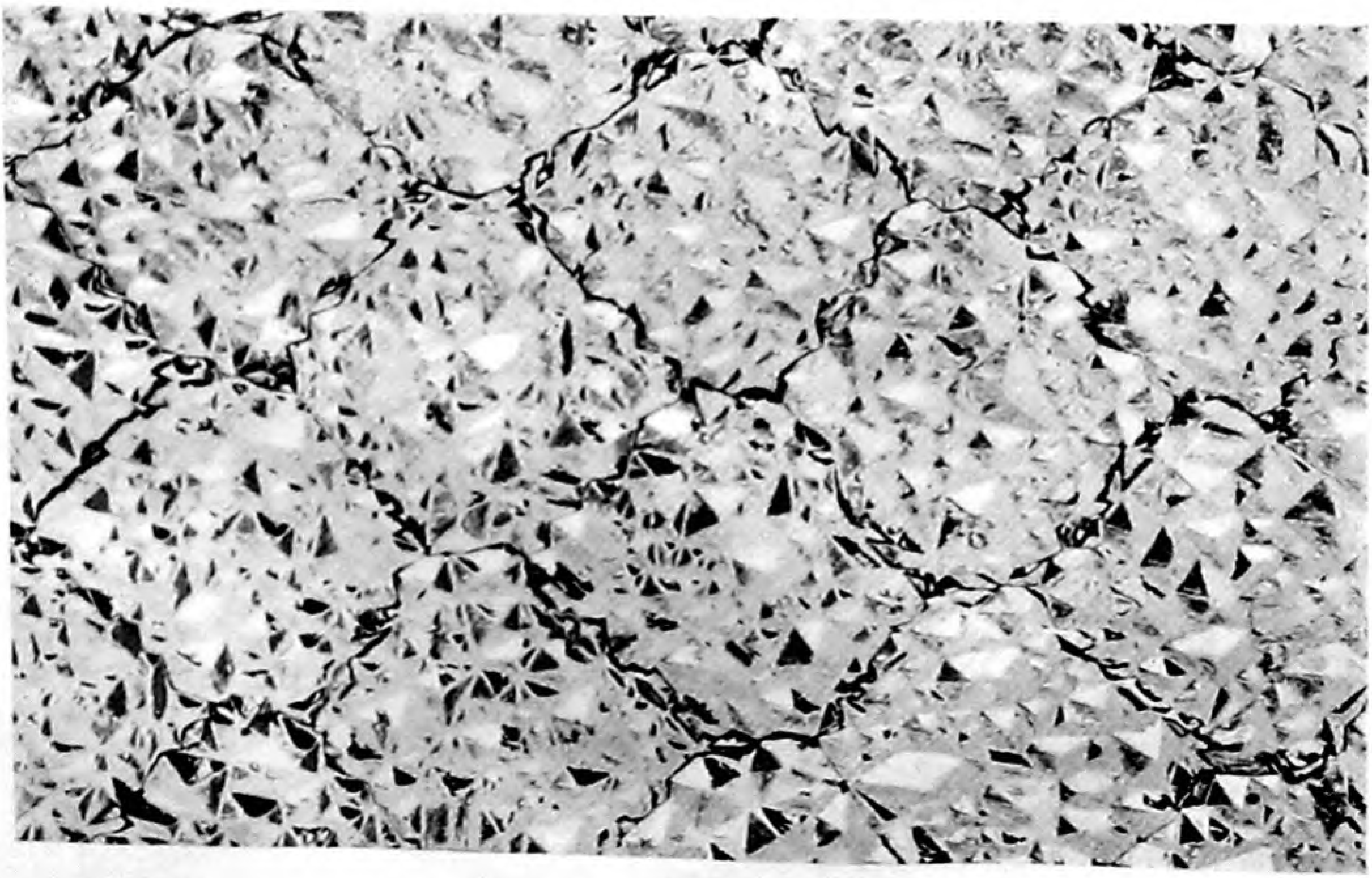


Plate No. 10. Wired Dewdrop.

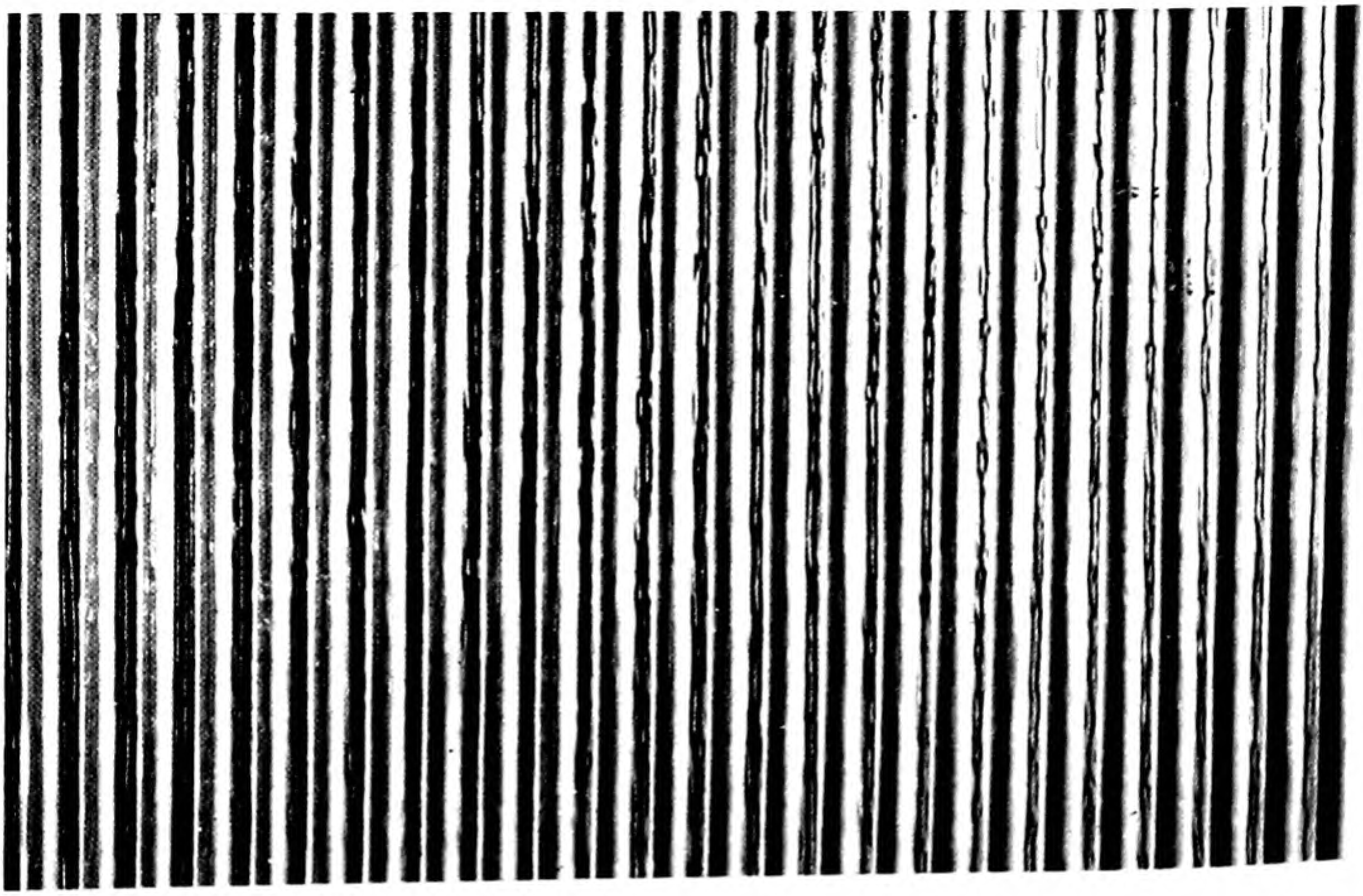


PLATE NO. 11. PRISMATIC ANGLE NO. 2.

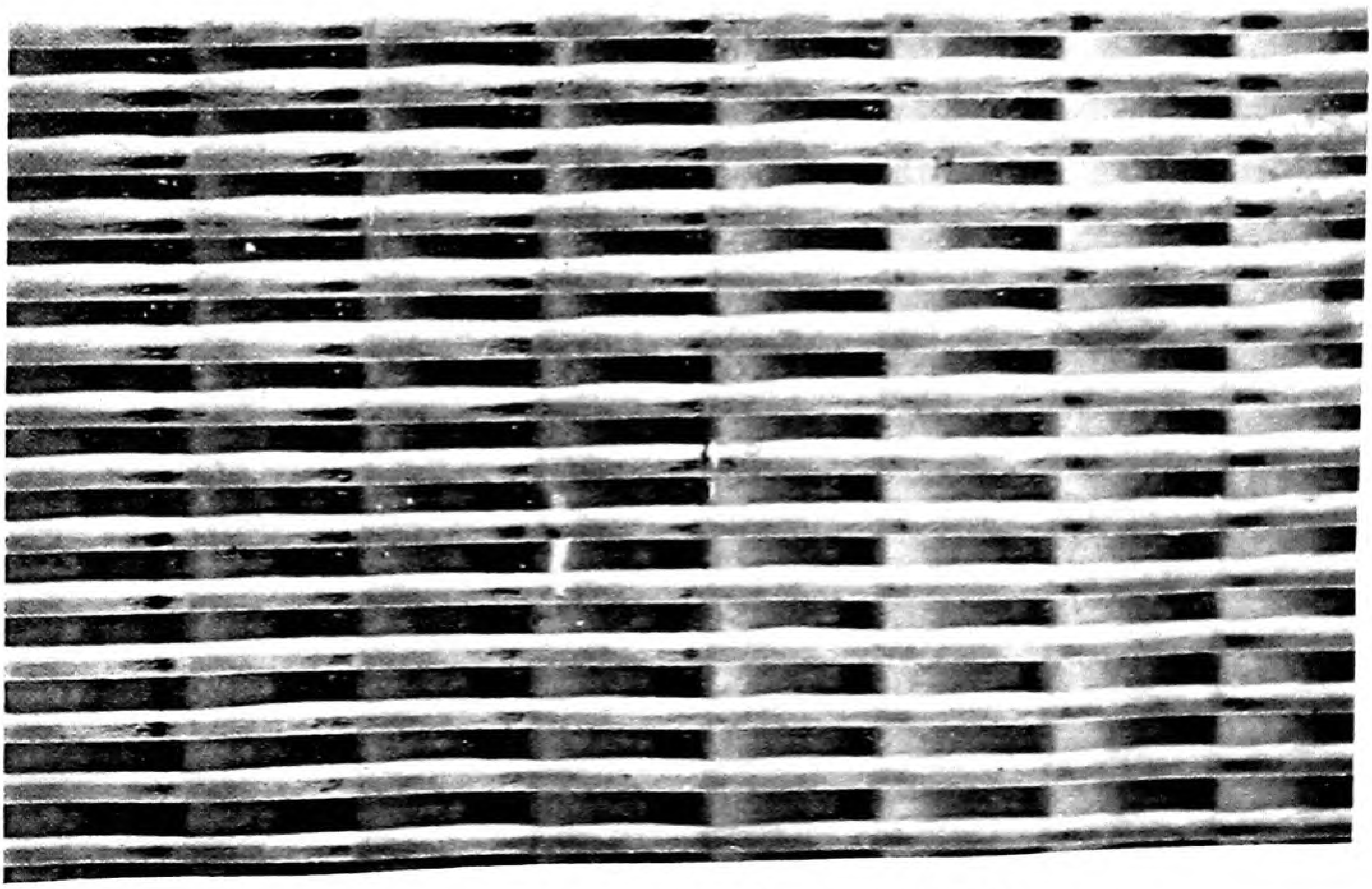


PLATE NO. 12. MAXIMUM DAYLIGHT GLASS.

CHAPTER IV

GLASS WALL AND FLOOR COVERINGS

Types and methods of fixing

THE impervious nature of glass, providing, as it does, a surface which is free from crazing and which can be cleaned merely by wiping with a damp cloth, makes it an eminently suitable material for wall coverings, both internal and external, for shop fronts as fascias, pilasters, stallboards, and for floor coverings when used with a roughened or rimpled surface.

Many of the rolled glasses already described, such as Feathered Washboard, Fluted, Reeded, Thick Rough Cast, etc., are used as wall linings, bath panels and for concealed lighting effects. They may be sandblasted, etched or silvered to provide a wide range of decorative effects.

Apart from these glasses, originally intended for other purposes, there are opaque glasses developed primarily for use as wall coverings. These are of both British and foreign manufacture, but only those of British manufacture are referred to in this chapter.

Such glasses may be classified under the following heads: (1) Ground and Polished Glass; (2) Rolled Glass with brilliant fire-polished surface; (3) Opal Glass; (4) Glass Tiles.

GROUND AND POLISHED GLASS

Opaque glasses of this type are made in two colours only: White Polished Opal and Polished Black Glass. They are produced in a similar manner to Clear Plate Glass, but are polished on one face only, the back being serated to provide a key for mastic fixing.

The standard thicknesses are: White $\frac{5}{16}$ in., $\frac{3}{8}$ in., $\frac{1}{2}$ in.; Black $\frac{3}{16}$ in., $\frac{3}{8}$ in., $\frac{1}{2}$ in., $\frac{3}{4}$ in., and 1 in. They are the most costly types of opaque glass and are used principally for door

architraves, skirtings, dadoes, bath panels and other positions subjected to rough usage, and for exterior work. They may be toughened to increase resistance to knocks and to minimize risk of breakage due to sudden changes in atmospheric temperature.

Black 'Toughened' Glass can be supplied in $\frac{5}{16}$ in. and upwards in sizes up to 70 in. by 54 in. It is used extensively for shop fascias, and there are a number of examples of its use for complete façades of buildings.

ROLLED OPAQUE GLASS WITH BRILLIANT FIRE-POLISHED SURFACE

This is manufactured under the trade name of 'Vitrolite,' and is glass in a devitrified form, produced by the addition of fluorides, such as cryolite, fluor-spar or sodium-silico fluoride. It is rolled to produce a brilliant fire polish on the face, the back being ribbed to provide a grip for mastic fixing.

It is supplied in black, white, ivory, green, eggshell, pearl grey, primrose, wedgwood blue, turquoise blue, shell pink, tango and some agate (marbled) effects. The standard thicknesses are $\frac{5}{16}$ in. and $\frac{7}{16}$ in. in white, black and colours, and $\frac{3}{4}$ in. and 1 in. in black and white only. For all internal wall linings, $\frac{5}{16}$ in. thickness is standard and weighs $4\frac{1}{3}$ lbs. per square foot. It is supplied in standard ashlar panels with ground edges in the following sizes: 15 in. by 10 in., 15 in. by 15 in., 18 in. by 12 in., and 21 in. by 14 in. Of these, 18 in. by 12 in. is the most popular. Larger sheets can also be provided, but are more costly to fix. Sizes are usually about 60 in. by 36 in.

OPAL GLASS

White Pot Opal and Opal Sheet are used as surface linings, but chiefly for ceilings. They are made in 15 oz. and 21 oz. substances and have a slightly wavy surface like Sheet Glass. The normal glazing size is 24 in. by 24 in., and when used for ceilings a canvas backing is advisable for safety.

GLASS TILES

Several varieties are made, of which the following are the more common:

Rusts Vitrious Tiles. These are hand made, hand fired vitrious tiles having a brilliant sparkling matt finish. Standard sizes are 4 in. by 4 in. and 3 in. by 3 in. by $\frac{3}{8}$ in. thick; and in mosaics 1 in. by 1 in. and $\frac{3}{4}$ in. by $\frac{3}{4}$ in. They are fixed by the makers to a prepared cement screed. The overall thickness of tiles and bedding is $\frac{3}{4}$ in.

The tiles are obtainable in an almost unlimited range of colours, and are used for both walls and floors in bathrooms, restaurant cloakrooms, public houses, hotels, etc., and externally for swimming pools.

Whitefriars Glass Tiles. These are hand made solid glass tiles with an eggshell finish, made in plain colours and patterns of varied colours. Inscriptions can be painted on and fired. Standard size is 8 in. by 8 in. by $\frac{1}{4}$ in., but smaller sizes down to 1 in. by 1 in. can also be supplied. They are fixed by bedding solidly in Keene's Cement. Principal uses are for decoration in churches and other public buildings, bathrooms and fireplace surrounds.

FIXING OF GLASS WALL LININGS

The usual methods of fixing are : (1) With Mastic to prepared walls; (2) With screws to a wood backing or plugs; (3) With wood or metal fillets.

Mastic Fixing. This method has proved the most reliable for moderately-sized sheets and especially for standard ashlar panels. A hard, non-absorbent backing is required, such as a dry Portland Cement screed or hardwall plaster. This should be treated with one or two coats of a special sealer before the glass is applied.

After cleaning the ribbed back of the glass with a brush, daubs of mastic are applied to the back at 4 in. or 5 in. intervals. The panels are then pressed to the walls with a

rubbing motion providing an even bed for the mastic $\frac{3}{16}$ in. to $\frac{1}{4}$ in. thick. Panels should not rub together horizontally, but should be separated by material the thickness of a visiting card. After fixing is completed the joints are pointed up with a mixture of white lead and varnish. Pigments may be added where a coloured joint is required.

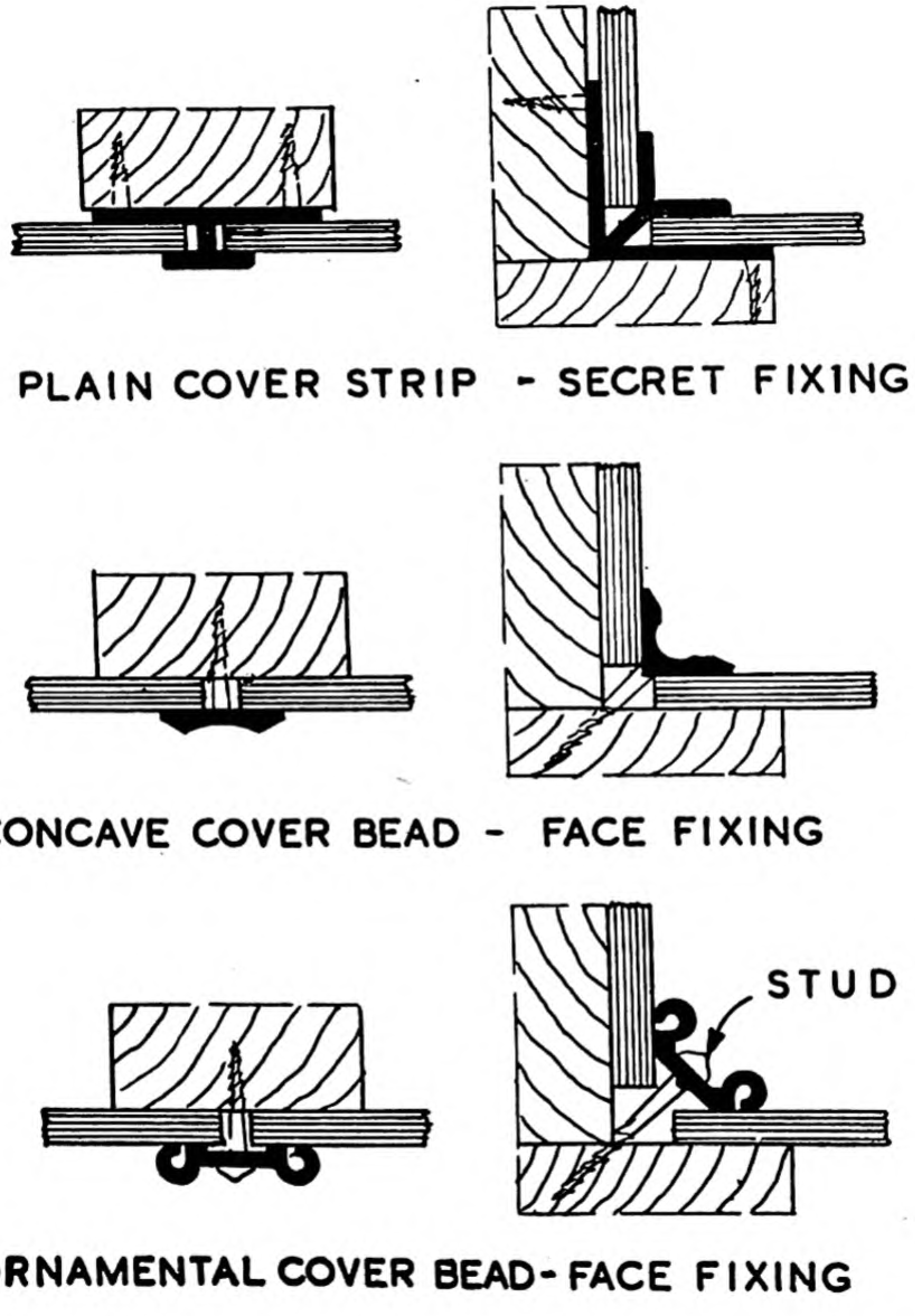
For external mastic fixing certain additional precautions are necessary. Expansion tape or felt should be placed under the bottom course of panels and between all horizontal joints. It should also be inserted wherever the glass comes against metal or other rigid material.

Special mastic is used for external work, and every second course should be supported on galvanised metal anchors.

Sizes of panels should be kept reasonable, not exceeding 40 in. by 30 in. on upper courses.

Screw Fixing needs little description. It is particularly suitable for bath panels and other positions where it may be necessary to gain access to concealed plumbing or wiring. Holes should be drilled of greater diameter than the fixing screws. In large panels it is advisable to use a spacing washer cut from a piece of brass tube, to allow for expansion and contraction of the glass. In fixing decorative mirrors special screws with decorative heads are used.

Wood or Metal Fillets. The use of cover strips has a tendency to detract from the appearance of any smooth wall finish, but this has to some extent been overcome by the use of metal strips such as aluminium, which can be anodised to provide a range of attractive shades. There are three general types of sections: (1) Secretly fixed sections; (2) Face fixed sections with screw heads finished with the same surface as the adjoining metal; (3) Face fixed sections with fixing screws hidden by oramental studs screwed in. Typical sections of these three types are shown in Fig. 4.



ALUMINIUM COVER STRIPS

FIG. No. 4

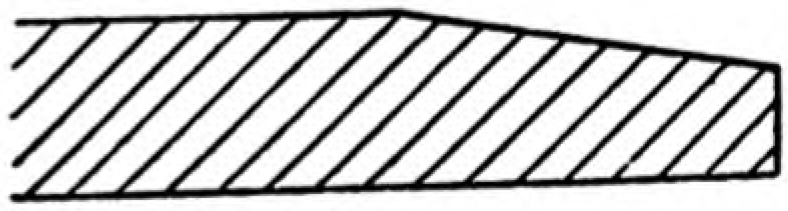
CHAPTER V

WORK ON GLASS

Bevelling—Edge Treatments—Brilliant Cutting—Silvering—Acid Embossing—Sandblasting—Deposition of Metal—Bending

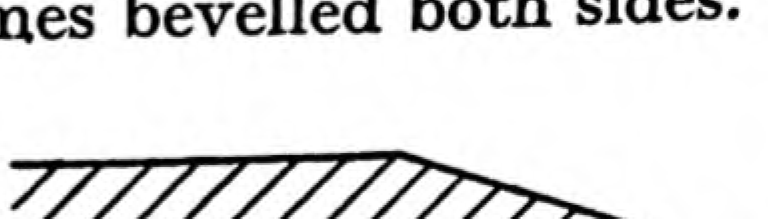
BEVELLING. Bevelling consists of the removal of a fixed width from the surface of the glass leaving the edge as cut by the diamond. This surface may be ground, smoothed and polished, or ground and smoothed, or ground only, according to the finish required. A cast-iron wheel is used for rough grinding with sand and water. Smoothing is carried out on a sandstone wheel, and polishing on willow wood wheels, first with powdered pumice and afterwards with rouge (iron oxide). In hand bevelling the glass is held over the wheels and the widths checked as the work proceeds. Most straight work is now carried out on machines in which either the wheels or the glass is tilted to the required angle. The following are the principal varieties:

Ordinary:



Widths: From $\frac{1}{4}$ in.-3 in.
$\frac{3}{4}$ in.-$1\frac{3}{4}$ in., normal for wardrobe doors and plates up to 15 ft. super.
$1\frac{1}{2}$ in.: large café mirrors.
1 in.-2 in., normal for clear plate indoor panels, etc. Sometimes bevelled both sides.

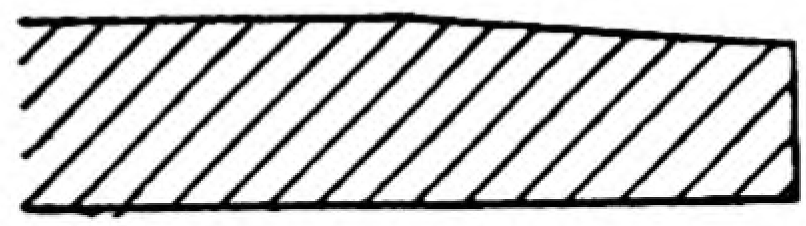
Feather Edge or Steep Bevel:



Sharply inclined bevel sometimes used for decorative purposes.

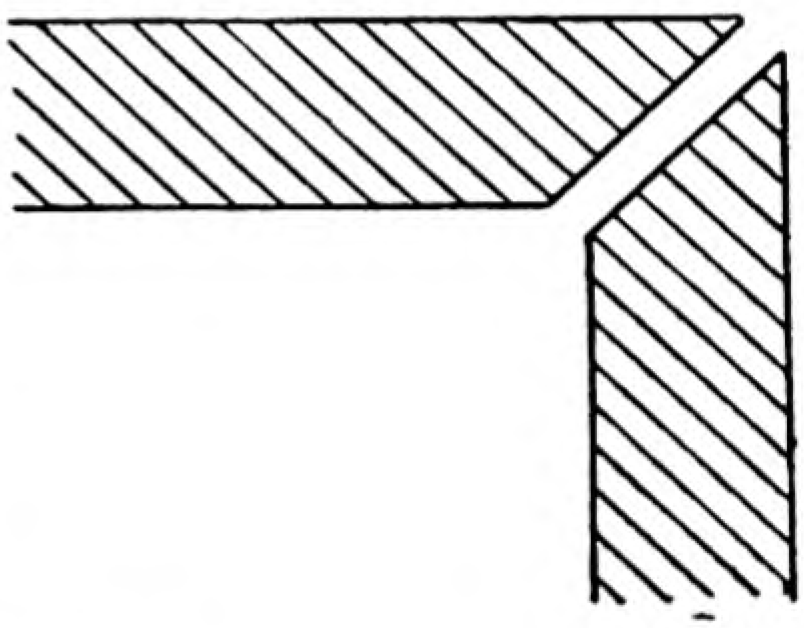
Vauxhall:

An earlier type with very slight bevel, having no clearly defined back edge. Now used mainly for antique reproductions.



Mitre Bevel:

Carried out on bevelling machines in order to give a close fitting joint. Used for frameless shop fronts and mirrored columns. A smooth finish should be specified for the former and a polished finish for the latter. Where a sharp edge is to be avoided mitre bevelling of both sides may be employed.

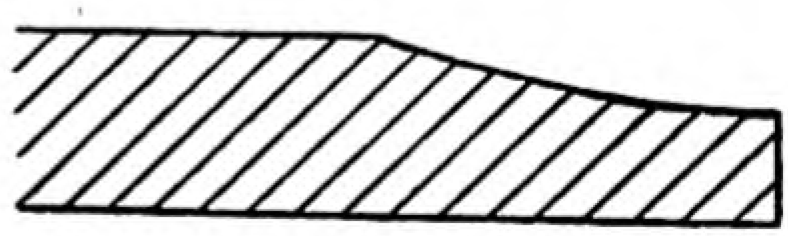


Reeded Bevel:

Consists of a series of brilliant cut shallow grooves along line of intersection of bevel with surface of glass.

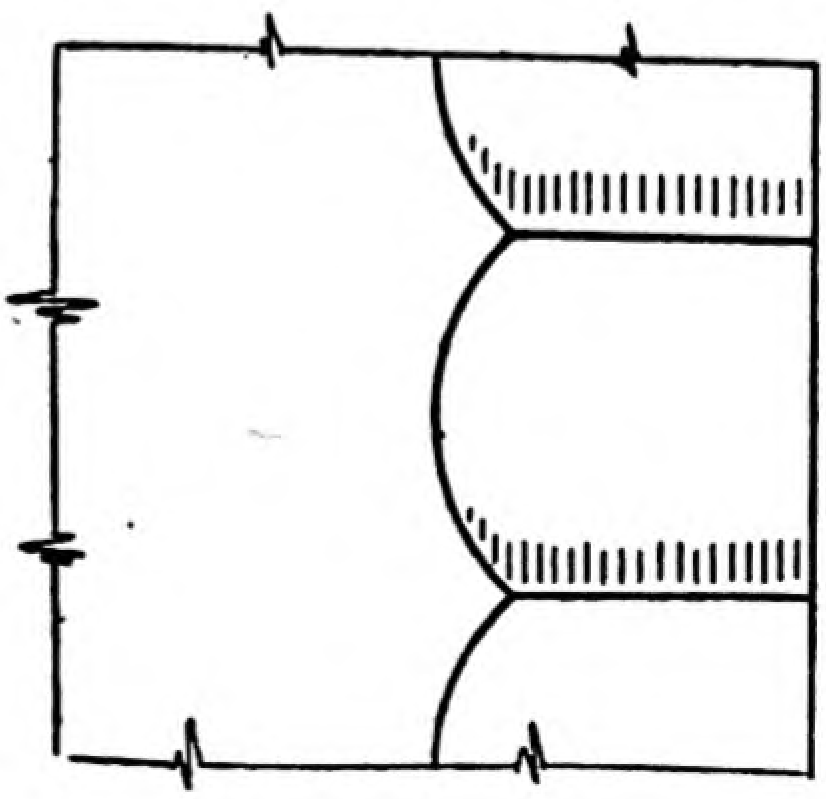
Scalloped or Fluted Bevel:

A series of scallops intersecting surface edge of glass.



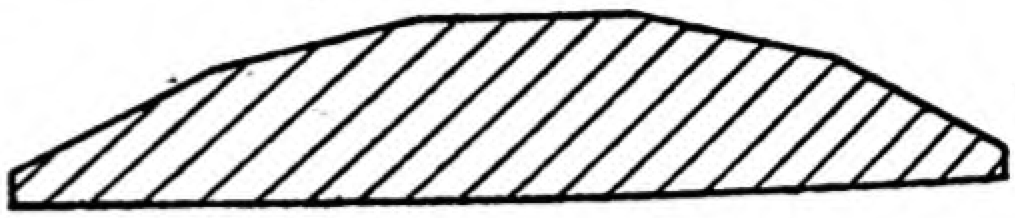
Thumb or Fluted:

A decorative finish used for frameless mirrors, etc. It is done on the brilliant cutting wheel. The maximum economic size is 10 ft. super.



Five Facet:

This section is used for decorative strips for mirrors,etc. Can be done in shapes as well as straight work. Usually carried out in coloured plate.



Maximum sizes: $1\frac{1}{4}$ in.-$3\frac{1}{2}$ in. wide up to 42 in. long.
$3\frac{1}{2}$ in.-6 in. wide up to 80 in. long.

EDGE TREATMENTS

Arrising. Taking off sharp corner to make plate safe for handling.

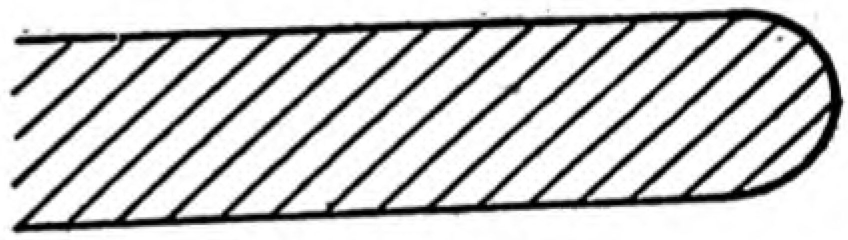
Grinding. Produces a level but obscure surface. Satisfactory when edge is inserted in a groove or covered by a bead, but not when exposed.

Polishing. Follows grinding and produces a permanently shiny surface. Used for frameless mirrors, table and furniture tops, shelves, etc.

TYPES OF FINISH

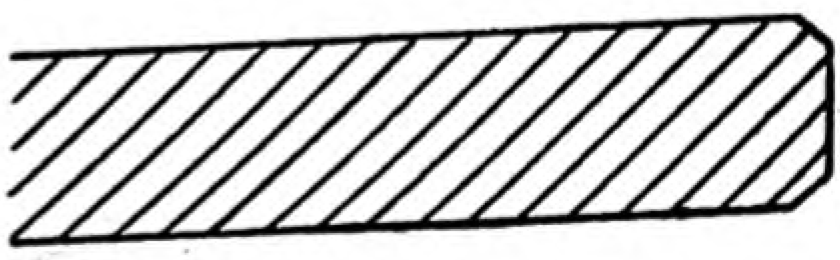
Round Edge:

Maximum sizes 100 in. by 100 in. Straight work is generally produced on special mass production machines.



Flat:

Maximum sizes: 130 in. by 90 in., 120 in. by 100 in. on machines.

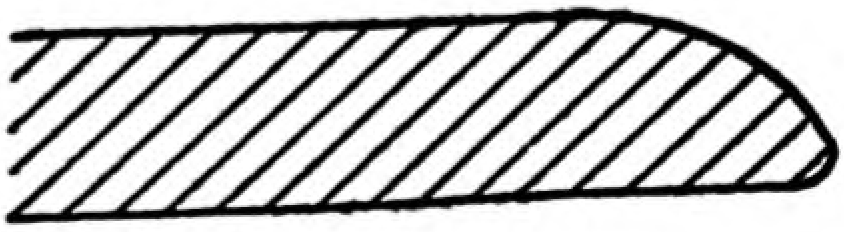


Larger sizes can be finished by hand, but at greatly increased cost.

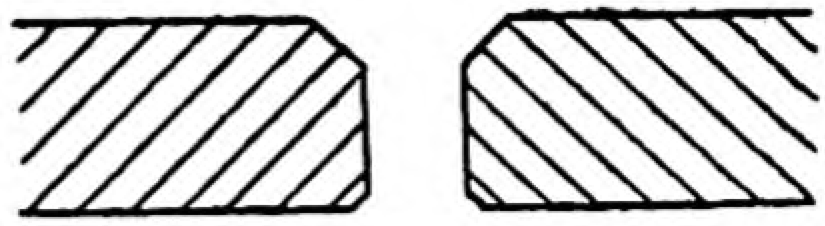
Thumb or Bull Nose:

Maximum sizes: 80 in. by 24 in., 60 in. by 30 in.

This finish costs approximately 50% more than flat or round polishing.



Butt Joint with Polished Arris: Used for sectional mirrors, glass wall linings, etc.

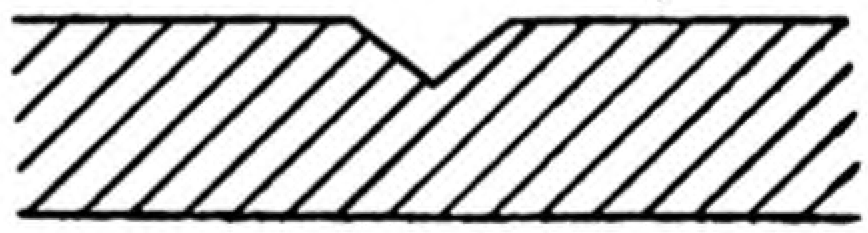


BRILLIANT CUTTING. This is a highly specialised craft and is one of the oldest methods used for the decoration of glass and glass ware. The work is done entirely by hand, balance weights being used to take the weight of the plate, which is held over a revolving sandstone wheel which cuts a line on the surface of the glass. This is afterwards polished by holding over a revolving willow wood wheel and finished off with a revolving fibre brush using rouge and water. Almost any design can be brilliant cut. Variations in width of cut and combinations of cut and hollows can give effect of leaves, flowers, etc. Stars are often cut, the most usual being a 32-point star. Brilliant cutting on mirrors may be on the face or the back. The latter facilitates cleaning, but any irregularities through polishing are shown up. The cut is sometimes left unpolished to form a more distinctive pattern.

Types of Line Cut:

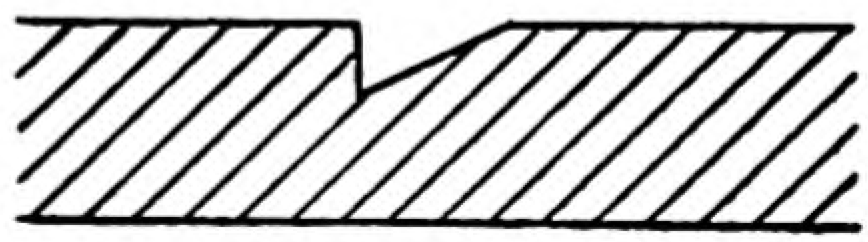
'V' Cut

Standard type. Usually $\frac{3}{16}$ in. wide.



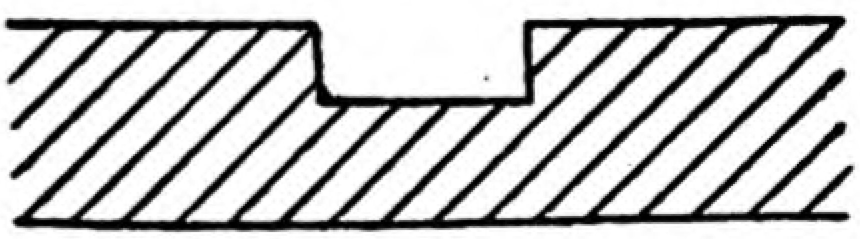
Edge Cut

For intricate designs, scrolls, etc.

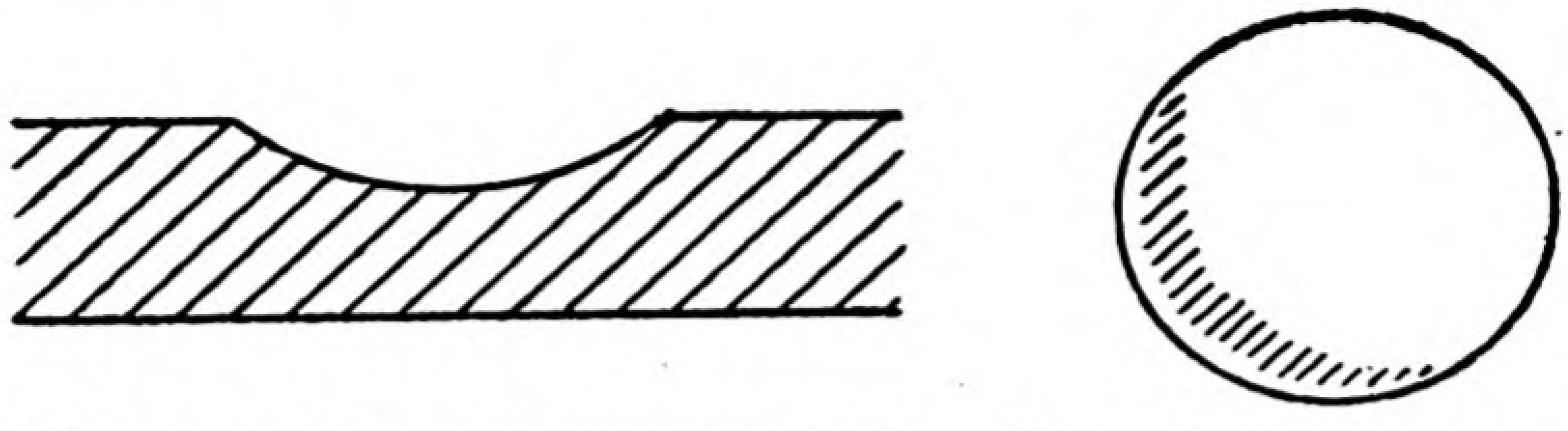


Panel Cut

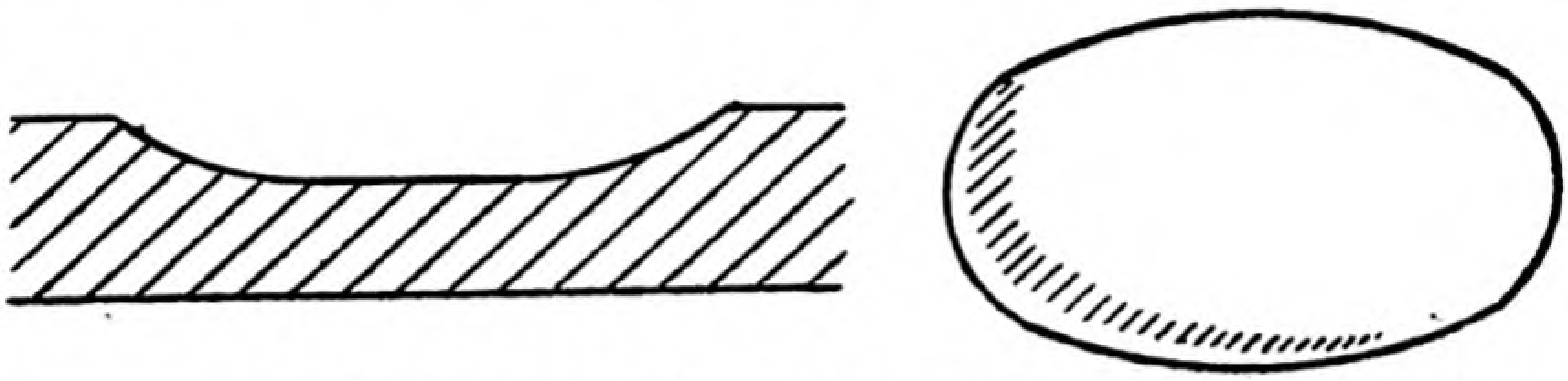
Straight lines only. Obtainable in widths of $\frac{1}{8}$ in., $\frac{1}{4}$ in. and $\frac{3}{8}$ in.



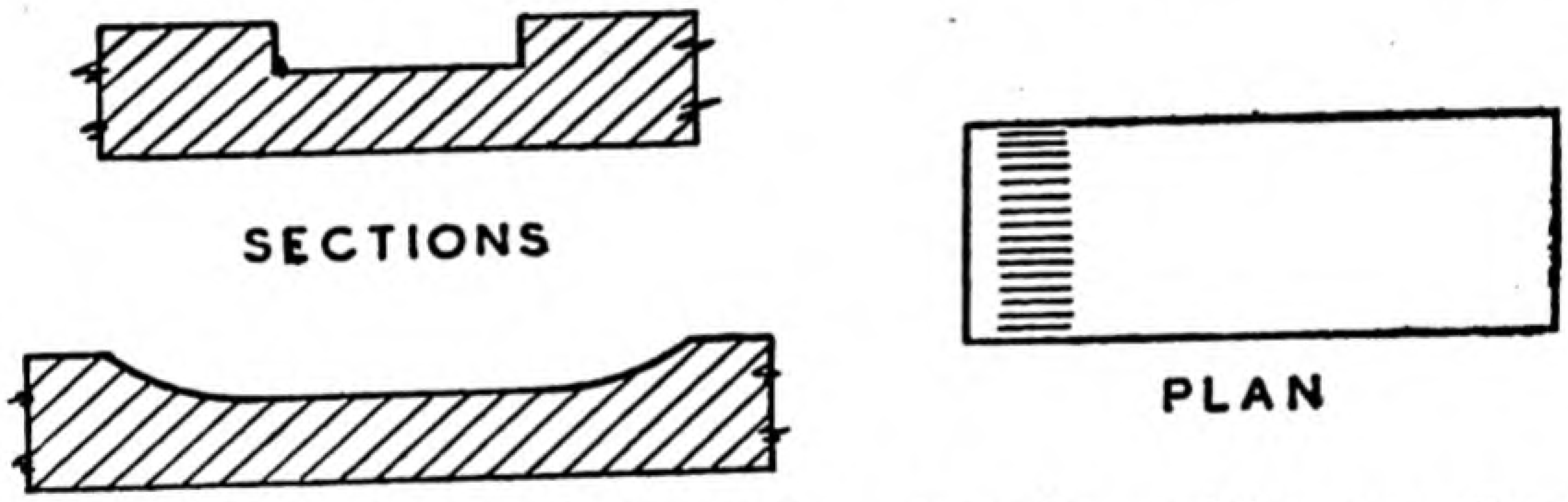
Specialities:



Round Punt: Maximum size 2 in. diameter.



Hollow or Oval Punt: $\frac{1}{2}$ in.-$\frac{3}{4}$ in. wide, up to 4 in. long.



Finger Grips: $\frac{1}{2}$ in., $\frac{3}{4}$ in., $\frac{7}{8}$ in. or 1 in. wide, up to 3 in. long. Standard $\frac{3}{4}$ in. by $2\frac{1}{2}$ in.

SILVERING. The earliest form of silvering consisted of coating the glass with an amalgam of tin and mercury. This process, though occasionally used for the reproduction of antique mirrors, has been superseded by the deposition of silver.

In this latter process all grease is removed from the surface of the glass, using a felt pad with a mixture of ammonia and whiting and afterwards swilling with distilled water. The silvering solution, consisting of a solution of some silver salt, such as silver nitrate, and a reducing

solution, is poured on to the surface of the glass. Deposition may take between three and twenty minutes, and either cold or hot solutions may be used. The spent solution is then removed, the surface washed with distilled water and dried with a chamois leather.

The silvering is protected by a coating of shellac, followed by a coating of a suitable paint or composition. A lead sheathing may be applied where the mirror is to be used in a damp or steamy position.

Pewter and gold may be deposited in a similar way, but at an increased cost.

For standard mirrors, S.G. quality Plate Glass is used, and for high class work S.Q. quality, both in ¼ in. thickness. For wall surfaces where a true reflection is important Planimetrie Plate Glass is used. Coloured effects are obtained by silvering on tinted plate, i.e. blush mirrors.

Silvering may also be applied to many of the Rolled Glasses now increasingly used for decorative work.

Designs may be carried out using a combination of two or more processes, such as Silvering, Gold Deposition, Pewter Silvering, Aciding, Painting, and leaving transparent.

ACID EMBOSSING. This process takes advantage of the fact that glass is soluble in hydrofluoric acid. By using this acid in conjunction with an alkali, such as ammonia, a dense white frosted surface is produced. There are six standard finishes:

(1) White Acid.
(2) Satin finish.
(3) Fine Stipple on Acid obscured (dull stipple).
(4) Fine Stipple on Clear (bright stipple).
(5) Middle Stipple on Acid obscured.
(6) Middle Stipple on Clear.

Examples of the above finishes as illustrated on Plate No. 13.

The satin finish is produced by a second acid treatment. The stippled finish is produced by the use of ground mica sprinkled over the surface of the glass before the acid is applied.

Various combinations of the above finishes can be made, such as: Double Embossing, a combination of two acid tones; Treble or French Embossing, a combination of three acid tones.

Acid embossing may also be used in conjunction with silvering, brilliant cutting, etc., in decorative panels.

SANDBLASTING. This is a method of obscuring glass by directing on to its surface a stream of compressed air and sand through a nozzle. By varying the size of the nozzle, the quality of the sand and the air pressure, various degrees of obscuration can be obtained. A metal, paper or rubber stencil is used with the parts to be sandblasted cut out.

Several finishes are possible:

Surface or Matt. This type does not bite deeply into the glass, but gives a flat obscured effect. It may be graded light or medium and applied either all over or to a design, leaving parts of the plate clear.

Deep or Gravé. This process bites deeply into the glass to one or more degrees of depth or graduated to give a moulded effect. The number of depths depends on the thickness of the glass. On $\frac{1}{4}$ in. Plate only two depths are normally used: $\frac{1}{32}$ in.-$\frac{1}{16}$ in. first depth and $\frac{1}{16}$ in.-$\frac{3}{32}$ in. second depth.

Peppering. In this finish the sandblast is lightly applied, leaving parts of the polished surface. Shaded effects can also be obtained and are most effective on opaque glass, such as Black Polished Plate or 'Vitrolite.'

A memorial window in sculptured glass, a good example of deep sandblasting, is shown on Plate No. 13.

Sandblasting may be used to cut unusual shaped holes, such as keyholes, and for the cutting of letters on flashed

opals, etc., for signs. It is frequently used in conjunction with other decorative treatments, such as silvering, acid embossing, brilliant cutting, etc.

DEPOSITION OF METAL. A further decorative finish on glass is the deposition of metal, either in the form of leaf, or as a metallic powder fused into the surface of the glass.

Gold or silver leaf may be applied to an acid etched or sandblasted surface, the satin finish providing an interesting contrast when applied to clear, mirrored or opal glass.

Silver, gold or platinum powder may be applied to the surface of glass and fused into it, producing a bright metallic finish which forms an integral part of the glass surface. This treatment is expensive and is sparingly used to pick out a design on coloured opal glass, and is particularly effective against a black background.

BENDING. Glass may be bent by heating in a kiln until it softens and takes the shape of the mould on which it is placed. Well-known examples are non-reflecting windows and glass domes.

CHAPTER VI

GLASS SILK

Manufacture—Properties—Uses in Heat and Sound Insulation and Acoustics—Other Uses

A COMPARATIVELY modern development in the glass industry is the manufacture of Glass Silk or Fibrous Glass.

The use of glass in fibrous form is by no means new, patents having been taken out as far back as 1822, but it was only during the Great War and the years following that the process of drawing glass fibres became industrialised.

In the earlier method of manufacture high grade broken glass, generally broken milk bottles, was fed into small electric furnaces having a series of nozzles at their base. The threads of molten glass were attached to a revolving drum and the silk wound until the required thickness was obtained. It was then cut to lengths of about 9 feet (the diameter of the drum) and passed for processing into one of the various forms in which it is marketed.

One of the most important developments in the production of Glass Silk for general insulation purposes was the introduction in 1931 of a steam blast in the drawing of the fibres. This process produced short or 'staple' fibres ranging in length from 4 to 16 in.

Improvements in the mechanical drawing process have made possible the production of 'continuous filament' textile fibres used in the production of fabrics and insulating tapes for electrical work.

The chief characteristic of Glass Silk used for insulation purposes is that the glass fibres are loosely packed to enclose the maximum air space. At a density of 12 lbs. per square foot about 92% of the space occupied by Glass Silk is air.

The following are the standard forms in which Glass Silk is produced:

Quilts. This is the form most commonly used for the insulation of timber walls, floors and roofs. It consists of a layer of glass fibres between two sheets of waterproof paper stitched together with thread. It is made in one yard width and in $\frac{3}{4}$ in., 1 in., and $1\frac{1}{4}$ in. thicknesses (uncompressed), referred to as Light, Medium and Heavy Quilt respectively. The standard length for Light and Medium Quilt is 27 yards, and for Heavy Quilt $13\frac{1}{2}$ yards. Light Grade is the standard for all ordinary work. It is fixed by nailing through metal washers supplied with each roll.

Ravelled or Loose. In this form Glass Silk is used for filling cavities to provide both heat and sound insulation. It is generally packed to a density of $6\frac{1}{2}$ to 8 lbs. per cubic foor. Apart from its use in buildings, there are applications in aircraft and general engineering work. It is an ideal material for the insulation of cookers and stove cases, refrigerators, etc.

Sheets. These are used for covering large surfaces, such as tanks, large diameter pipes, etc. They are secured by wire or straps so as to lie close to the surface to be insulated. They are supplied in sheets 18 in. or 36 in. wide by 9 ft. long or in special cut sizes, and in $\frac{1}{2}$ in., $\frac{3}{4}$ in., 1 in., $1\frac{1}{4}$ in. and $1\frac{1}{2}$ in. thicknesses. Greater thicknesses can be built up from standard sheets.

Mattresses or Blankets. These consists of Glass Silk enclosed in wire netting, asbestos cloth or other covering and are particularly suitable for positions where the insulation may require to be removed easily and quickly. They are also used for acoustical purposes. Any thickness can be made in standard sizes up to 10 ft. long by 38 in. wide. They can also be purpose made in special sizes and shapes.

Flexible Sections. This is the form most commonly used for pipe insulation. The sections are made in lengths of 3 ft. and in widths to suit all sizes of pipes. They are applied by laying them along the pipes and forming them round until

the edges butt together. They are held in place by tie wire and covered with canvas or hard setting composition, or other finish as desired.

Strips or Bandage. This is a convenient form for insulating pipes up to 6 in. outside diameter and is particularly suitable for bends, tee pieces, valve bodies, etc. It is supplied in rolls 9 ft. long, in widths of 2 in., 3 in., 4 in., and 6 in., and in thicknesses up to 1 in. backed with jute canvas, asbestos cloth or other suitable fabric. It can also be supplied unbacked.

Rigid Sections. These are the neatest in appearance and the simplest to apply of all types of Glass Silk Pipe insulation. The sections are made in 3 ft. lengths, in various thicknesses and moulded to fit closely on to pipelines from ½ in. to 12 in. outside diameter. They are in the form of a tube and are split longitudinally so that they can be sprung on to the pipe and secured by metal bands which are supplied. They are made with a covering of scrim cloth or white cotton canvas as desired.

Special Sections. These are made in the form of removable metal covers, lined with Glass Silk, for covering steam fittings such as valves and flanged joints.

Fabric. Both 'staple' and 'continuous' fibres may be used to produce a yarn which, in turn, may be woven into cloth tapes, sleevings, etc., used for electrical insulation. For this application a special 'alkali free' glass is used which has high insulation resistance, high durability and what is termed 'good dielectric strength.' The durability, non-inflammability and permanence of colour or cloth woven from Glass Silk places this material as one of the future fabrics for interior decoration.

NaCl + Glass → O

GENERAL PROPERTIES

As the insulating medium consists entirely of glass, in conjunction with numerous air spaces, the product is non-corrosive, non-hygroscopic, odourless, non-inflammable,

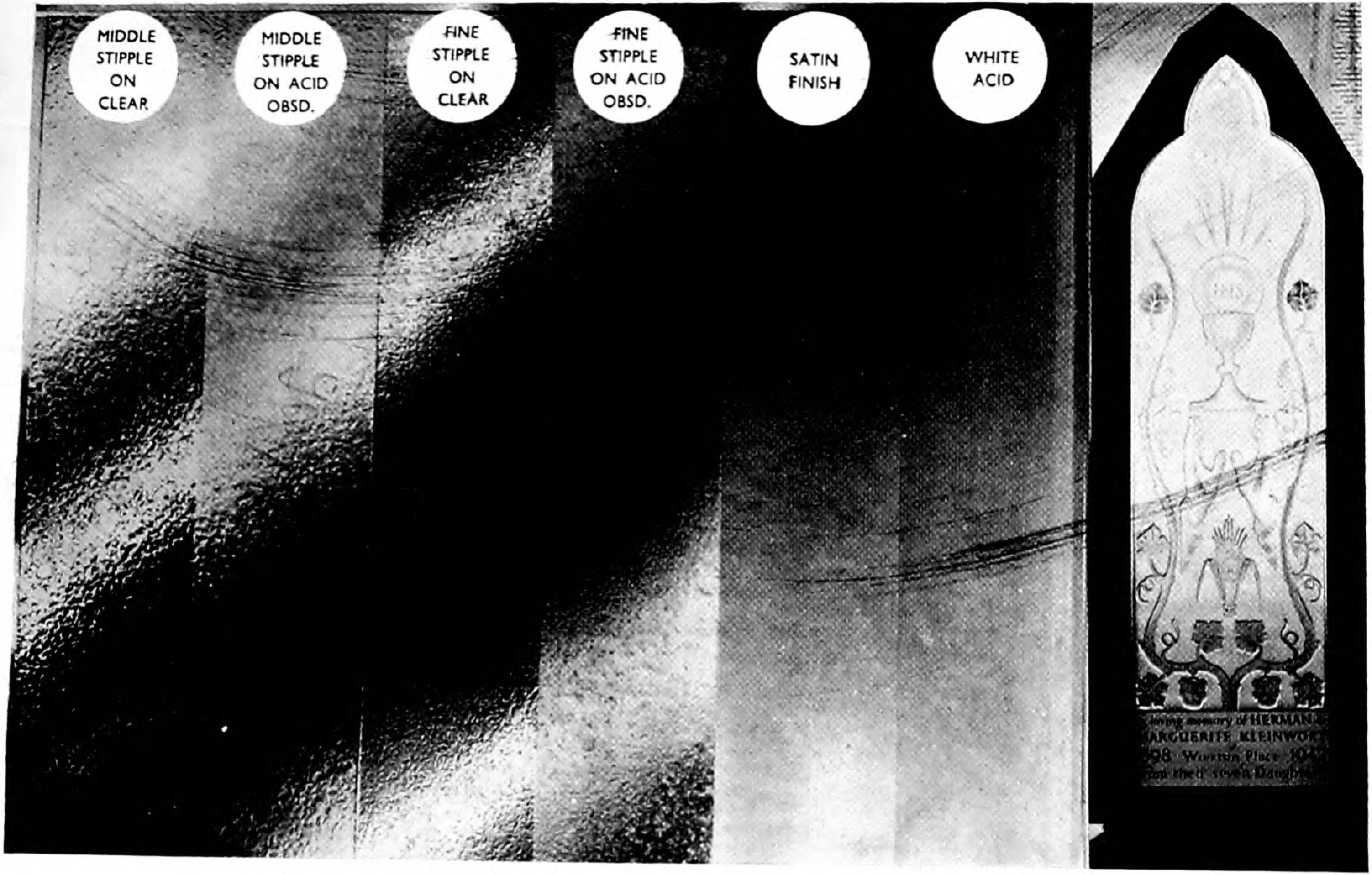


PLATE No. 13. WORK ON GLASS.

vermin proof and will withstand temperatures up to 1,000°F. It is light in weight and will not settle under vibration.

The combination of these properties make Glass Silk eminently suitable for all kinds of heat insulation at temperatures up to 1,000°F., sound insulation, acoustics and also as a filter medium in ventilation and air conditioning.

HEAT INSULATION

Pipe Coverings, etc. The thermal conductivity of Glass Silk in its various forms ranges from .02 to .06 B.T.U.s per square foot per hour per degree Fahrenheit per foot thickness for pipe temperatures of 100 to 900°F. The actual figures are shown graphically in Fig. 5, which is based on N.P.L. results and compares these with values for other pipe insulating materials.

Roofs, Walls, etc. In loose or blanket form, Glass Silk is an efficient insulator against heat or cold. Its non-inflammability, resistance to vermin and non-hygroscopic qualities make it an ideal material for use with timber construction. Its lightness in weight allows it to be laid in loose form direct on ceiling boards or lath and plaster.

The thermal conductivities at normal atmospheric and room temperatures for different densities are as follows:

Face Temperatures, °F.		B.T.U.s/sq. ft./hr./inch per °F. Difference.	Approx. Density. Lbs./Cub. Ft.
Cold.	Hot.		
32	68	0.23	3
32	70	0.22	5

SOUND INSULATION

It is generally known that the most effective and economical method of insulating against the transmission of airborne sound is to use mass, as, for example, a brick or concrete wall. In many instances this is not possible and it is here that the light weight insulating materials are valuable.

If a cavity is split up into two separate air spaces divided by a resilient quilting, a comparable effect to a solid wall is obtained. Here again the vermin and fire resisting qualities of Glass Silk make it an ideal material for this form of insulation.

When laid under floor boards it also provides additional insulation against impact noises. As the latter are readily transmitted through concrete floors, the use of Glass Silk quilts under the battens provides a noise reduction factor of 15-20 units, which is considered adequate for all ordinary conditions.

SOUND ABSORPTION

Glass Silk may be used as an acoustical material for the lining of walls and ceilings of auditoria to prevent reverberation and echo. For this purpose the surface must not be covered by any impervious material. It is generally used in mattress form with the front surface faced with open mesh asbestos cloth and covered on both sides with wire netting. It is generally fixed by nailing to wood battens.

The coefficient of absorption, as measured by the National Physical Laboratory on a specimen 10 ft. by 10 ft., 1½ in. thick and weighing 16 lbs. per square yard is as follows:

FREQUENCY (cycles per second)

250	500	1,000	2,000	4,000	6,000
0.75	0.90	0.90	0.90	0.95	0.85

VENTILATION AND AIR CONDITIONING

Glass Silk is used sucessfully as a filtering medium for the removal of dust and other impurities in air cleansing installations. It is formed into a self-contained filter unit of the throw away type, which, when fully charged with dust and impurities, is discarded and replaced by a fresh unit.

The glass fibres are criss-crossed and held together by a flexible binding agent and sprayed with a special viscous

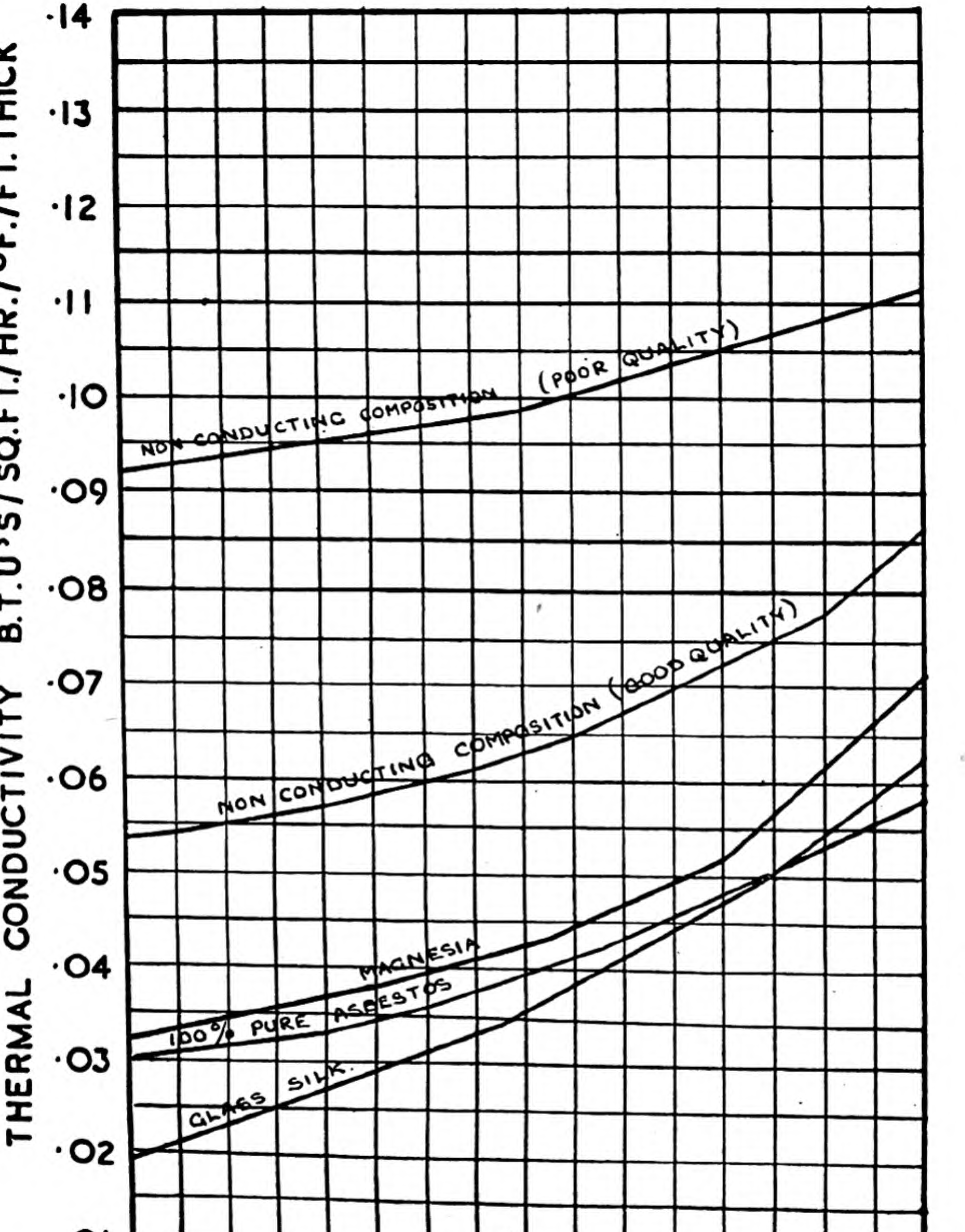

THERMAL CONDUCTIVITY B.T.U'S/SQ.FT./HR./°F./FT. THICK
·14
·13
·12
·11
·10
·09
·08
·07
·06
·05
·04
·03
·02
·01
100
200
300
400
500
600
700
800
900
PIPE TEMPERATURE °F
NON CONDUCTING COMPOSITION (POOR QUALITY)
NON CONDUCTING COMPOSITION (GOOD QUALITY)
MAGNESIA
100% PURE ASBESTOS
GLASS SILK

FIG. No. 5

medium. The coated pack is placed between two light metal grilles and the whole contained in a strong chipboard frame. The units are made in a uniform thickness of 2 in. and a range of standard sizes.

The special features of this type of filter are its durability, high efficiency of dirt extraction, low resistance to air flow, large dust-holding capacity, ease of handling and replacement, and ability to retain filtering properties over an adequate period of time.

CHAPTER VII

GLAZING

Mastics—Window Glazing—Leaded Lights—Patent Roof Glazing—Copper Lights

Mastics

The term 'mastic' is used here in its broadest sense, to cover all glazing compounds whether setting or non-setting. These may be classified according to the material of which the sash or frame to be glazed is composed: wood, metal, stone, etc.

For the glazing of wood sashes, linseed oil putty is used. This consists of raw linseed oil, powdered whiting, and, in some cases, a hardening agent such as red lead. The excessive use of hardening agents may cause crazing and should be avoided. Pigments, such as umber, ochre, Brunswick black, etc., may be added in powdered form to colour the putty in order to match the woodwork. This is a point of importance with back putty where the sash is to have a polished finish. The hardening action is caused partly by the absorption of the linseed oil into the wood, but mainly by the oxidation of the linseed oil after exposure to the atmosphere. To allow proper setting to take place painting should be left until fourteen days after glazing.

In the case of metal windows no absorption of oil takes place and consequently a longer drying period is required before painting. To overcome this, hardening agents such as red or white lead, litharge, etc., have been used, but these have now been largely superseded by the use of special glazing compounds which harden by chemical action.

With the use of these compounds, painting can be carried out immediately after glazing, but it is advisable to leave for fourteen days.

For glazing in stone or concrete a mastic consisting of gypsum, loamy sand and oxide of lead is sometimes used. This is mixed immediately before use with boiled linseed oil. Neat Portland cement is sometimes used, but both of these mastics have the disadvantage of being hard setting and therefore do not allow for the movement of the structure. In recent years bituminous rubber compounds have been developed which form a watertight, yet elastic joint. They are also used for under-water lighting effects where absolute water tightness is required.

GLAZING

The term 'glazing' is defined in the British Standard Code of Practice for the Glazing and Fixing of Glass for Buildings as 'the term applied to the securing of glass in prepared openings to form windows, door panels, screens, partitions, etc.'

The methods and materials employed will depend on the nature of the casement or sash, whether wood, metal stone or concrete.

WOODEN CASEMENTS OR SASHES

Wood frames should receive a priming coat of lead paint to prevent excessive absorption of linseed oil and consequent shrinkage and cracking of the putty. This is carried out for the glazing contractor before glazing is commenced, very often in the works of the joinery manufacturer.

Fig. 6 shows a typical section of a wooden sash. The actual size of the opening which admits light is termed the daylight size or sight size. The rebate varies slightly in size according to overall width of sash bar. The dimension to the rebate opening is termed the tight size, rebate size or full size and does not provide a glazing clearance.

The glazing size or glass size for wooden sashes is the tight size less $\frac{1}{8}$ in. height and $\frac{1}{8}$ in. in width (or $\frac{1}{16}$ in. all round), termed the glazing clearance.

Two methods of glazing are usually employed:

(1) *With Putty.* Linseed oil putty is used and is applied to the rebate to form the bedding or back putty. The glass is firmly embedded in the back putty by pressing with the outstretched tips of the fingers, thus spreading the weight

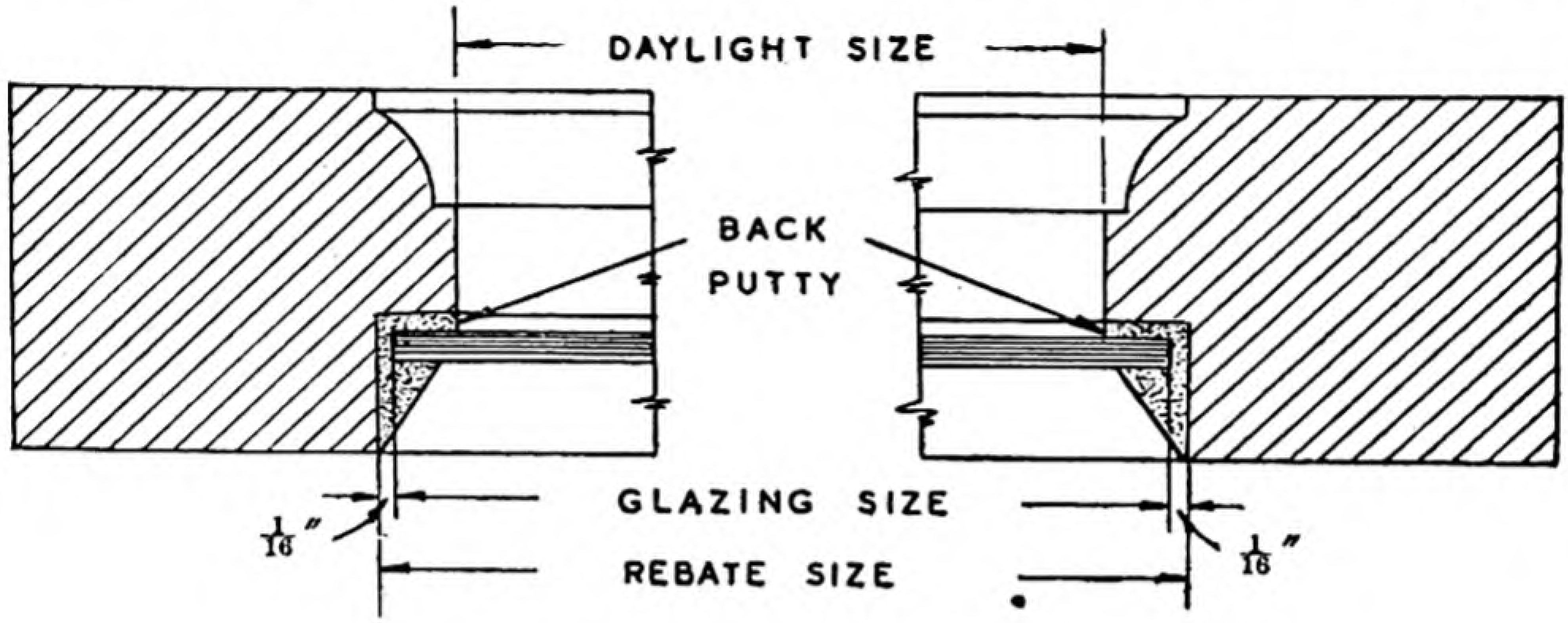


FIG. No. 6

over the greatest area, and securing with glazier's sprigs. These are generally small, almost headless, nails, but sometimes small triangular pieces of zinc are used which can be hammered into position with a square-edged chisel. The advantage of the latter is that they offer a greater surface to the glass and lessen the danger of cracking the pane.

After bedding and securing, front putty is applied, which should stop $\frac{1}{16}$ in. to $\frac{1}{8}$ in. from the sight line of the back of the rebate, so that the painter can point up to the sight line and seal the edge of the putty to the glass. Painting should be left until the putty has set.

(2) *With beads.* These are sometimes employed for inside glazing of sashes or for door panels and screens. The beads should be of the same wood as the frame and may be fixed by means of nails or brass screws and cups. The glass may be bedded in putty or, for inside screens and doors, in wash leather, ribbon velvet, rubber or felt. These should be formed into channels so as to protect all parts of the glass coming into contact with the rebate or the bead.

METAL CASEMENTS

The metals used in the manufacture of metal casements are principally mild steel, bronze and aluminium. Mild steel is by far the most common and the least expensive. It may be protected by means of a rust inhibiting paint, such as red lead, or with red iron oxide stoved at a temperature of about 260°F. Alternatively, it can be zinc coated by hot galvanizing, cold galvanizing (or zinc electroplating), Sherardising, Parkerizing or other patented process.

Bronze or, more correctly, extruded brass and aluminium are becoming increasingly used in office and public buildings where permanency with the minimum of maintenance is more important than first cost.

The glazing size for metal sashes is the tight size, or rebate size, less $\frac{1}{8}$ in. all round.

Four methods of glazing are usually employed:

(1) *Outside Putty Glazed.* This is the most common and also the most economical method. It has the advantage over inside putty glazing in that wind pressure does not throw strain on the putty. Above ground level it is equal in appearance to any other method.

The glazing procedure is similar to that described for wooden sashes, with the exception that, after bedding, the glass is secured by pegs or clips inserted in holes already provided to receive them, and special glazing compounds are used in place of linseed oil putty.

(2) *Inside Putty Glazed.* This is used where external appearance is more important than internal appearance, or where replacement of broken panes is more easily effected from the inside. It is not so resistent to wind pressure as external glazing and panes should not exceed 12 ft. super. The bedding, fixing and face puttying are as for outside putty glazing.

(3) *Inside Beaded.* This method is used where there is difficulty in replacing glass from outside, and where a better

internal finish than putty glazing is required. It is used for all sliding sashes.

Beads are generally of wood, but for fire escape stairs, and other situations where local by-laws prohibit the use of timber, metal beads are used. The most suitable timber is magnolia, but oak, teak and mahogany are also used. The glass is bedded in metal sash putty and the beads are fixed by brass or zinc-coated screws. Brass caps should be inserted in the beads to take the heads of the screws.

(4) *Outside Beaded.* This form of glazing is rarely used, except for shop fronts, which are described later. The beads may be of wood or metal as already described for inside beaded glazing.

Typical sections of metal windows showing examples of the above methods of glazing are given in Fig. 7.

GLAZING IN STONEWORK, CONCRETE OR BRICKWORK

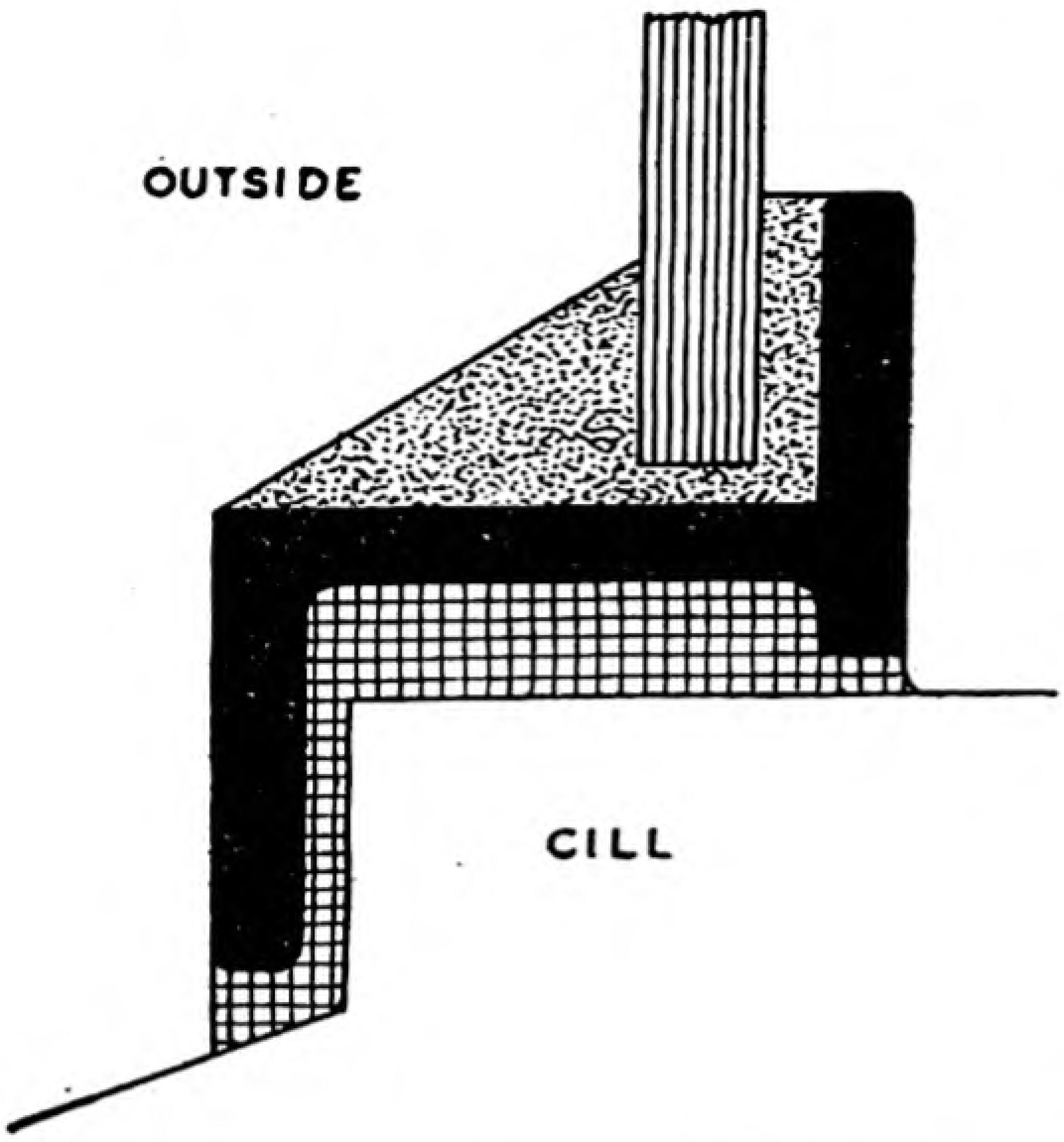
In traceried and mullioned windows of either brick or stone, metal or wood frames are often dispensed with and the glass fitted into grooves in the masonry. Mastics, as described on page 54, are used.

In contrast to these, ultra-modern effects can be produced by the use of concrete glazing bars with reeded, cross-reeded or fluted glass. The glass is again bedded into grooves in the bars with special mastic. Details of this type of construction are given in Chapter VIII.

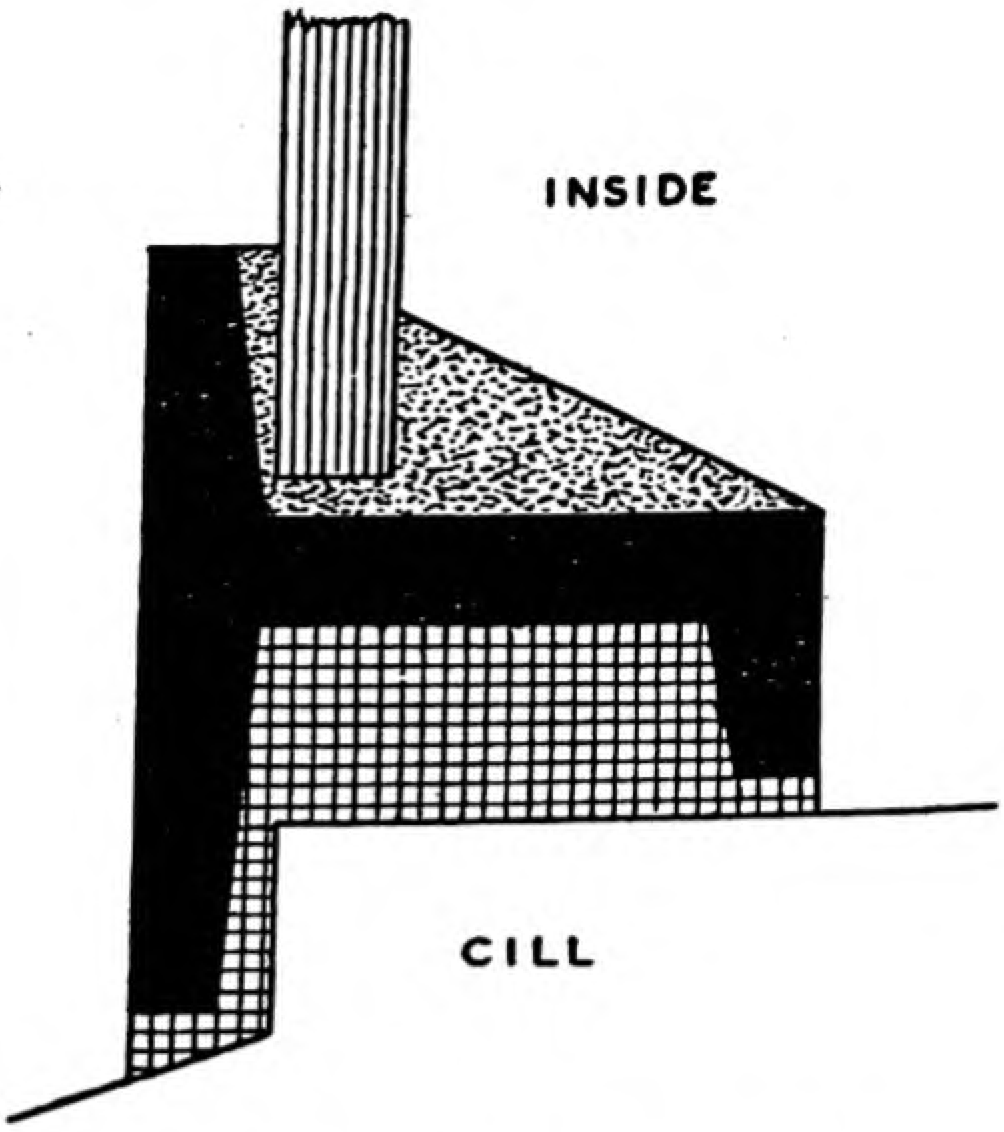
SHOP FRONTS

Frames may be of wood, solid metal or sheet metal drawn on hardwood cores. The principal timbers used for wood frames are oak, teak, mahogany and walnut. Metal frames may be of bronze (solid only), gilding metal and other brasses, aluminium and stainless steel.

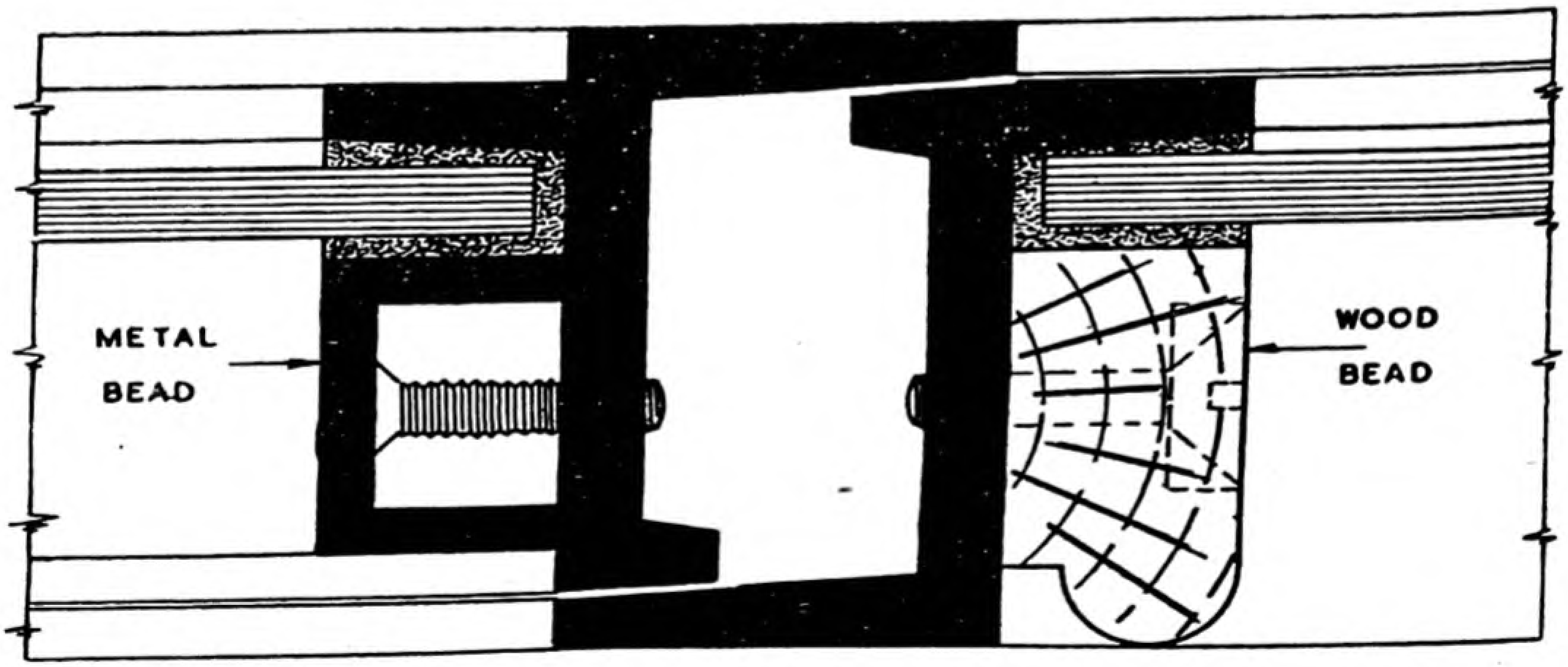
The glass is fixed by bedding in putty, tinted to match the frame, and secured by glazing beads of the same material as the frame. Beads may be on the outside or inside. The latter has the best appearance, but outside glazing allows



STANDARD METAL WINDOW
OUTSIDE PUTTY GLAZED



STANDARD METAL SASH
INSIDE PUTTY GLAZED



METAL WINDOW GLAZED WITH METAL OR WOOD BEADS

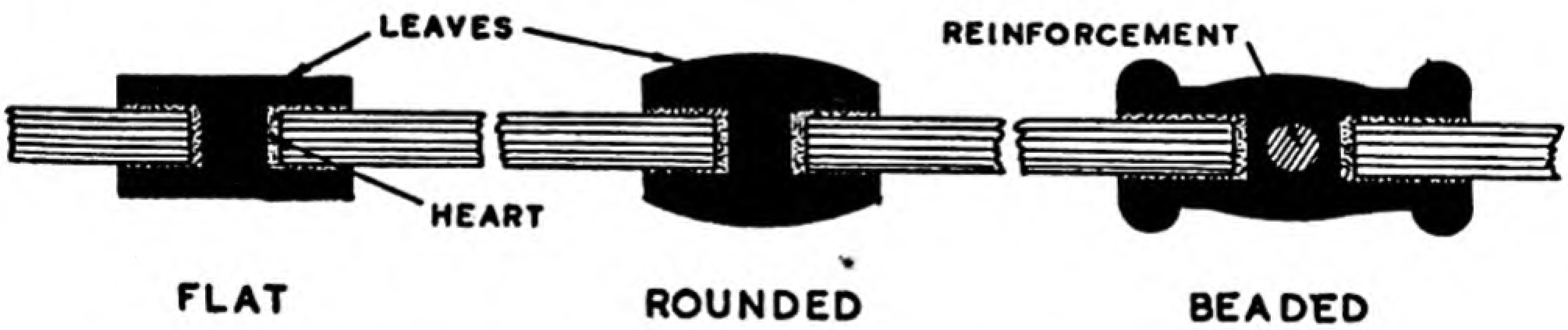
FIG No. 7

the glass to be unloaded in the street and fixed straight into position. Outside beads should be bevelled to shed the rain. Frameless glazing is sometimes used at the junction of two panes of glass on the angle in order to give an uninterrupted view of the display. The edges of the glass are mitre bevelled and held together by stainless steel or chromium-plated clips, spaced at approximately 2 ft. centres, and bolted to the glass. In some cases the edges are coated with a transparent cement.

LEADED LIGHTS

The manufacture of leaded lights is a specialised job carried out by skilled craftsmen to architects' designs or to certain standard patterns. In ordering, both the rebate size and daylight size should be stated. In specifying sizes of openings it is assumed that the first dimension given is the height.

The lead cames or glazing bars should be made from pure pig lead, cold drawn by hand in a compression vice. Hot extruded bars are also produced, but are less durable. The cames are of 'H' section; that part separating the glass, which provides the strength of the bar, is termed the heart. The sides which cover the joint of the glass are termed the leaves.



TYPICAL SECTIONS OF LEAD CAMES

FIG. No. 8

The heart varies from $\frac{1}{16}$ in. to $\frac{1}{2}$ in. in thickness, and is sometimes steel reinforced, while the leaves, which may be flat, round or beaded, vary from $\frac{1}{8}$ in. to $1\frac{1}{2}$ in. in width (See Fig. 8).

The cames are sweated together, using fine solder composed of 50% tin and 50% lead. They are brushed with metallic putty to form a watertight seal between the lead and the glass.

Leaded lights may be fixed to metal or wood frames in the same way as plate glass, either with putty glazing or beads. In either case the leaded light should be bedded in putty and held in place with nails or clips.

In larger windows leaded lights should be reinforced by steel or bronze saddle bars, generally $\frac{3}{8}$ in. diameter and spaced 3 ft. apart. Where steel reinforced cames are used, saddle bars may be dispensed with, except in special circumstances.

Clear or patterned glass may be used for glazing leaded lights. Where an unobstructed outlook is required, clear rectangular panes not less than 4 in. by 5 in. should be used. Where obscuration is required the hand-made Cathedral and Antique Glasses or Cathedral Rolled Glasses are suitable (See Chapter II for details of patterns and tints available).

More elaborate work, such as memorial windows, heraldic designs, etc., are usually designed by artists who are specialists in this class of work and who in many cases also execute the work.

COPPER LIGHTS

Electro copper glazing is a process in which the pieces of glass are cut and ground to size and assembled with strips of copper between their edges. The whole is tightly compressed and the intersection of the copper strips touched with solder. The whole plate is then transferred to a plating tank, where copper is electrolytically deposited on to the edges and interstices of the strips. This deposited copper forms small bead-like flanges which hold the glass rigidly in position.

Panes can be of any shape and either clear or figured glass may be used.

Broken panes can be replaced at any time. The cames may be left rough or polished and may be chromium plated or treated to resemble bronze.

Copper glazing of this type is accepted as fire resisting, providing that:

(1) The glass is not less than $\frac{1}{4}$ in. thick.
(2) No pane exceeds 16 square inches in area.
(3) No plate exceeds 24 inches in either dimension.
(4) The plates are fixed in metal, hardwood or other recognised fire-resisting material.

PATENT ROOF GLAZING

The use of putty glazing on roofs, lantern lights and skylights involves a considerable amount of maintenance, and for this reason it has been superseded by puttyless or patent roof glazing usually carried out by specialist firms. Other disadvantages of putty glazing of roofs are that it does not allow for free expansion and contraction of the relatively long panes of glass, that the width of section required (for wooden glazing bars) offers increased obstruction to light, and that no provision is made for the collection of condensation.

The numerous types of patent glazing bars evolved by specialist firms successfully overcome many or all of these disadvantages. They may be classified under the following headings:

(1) Lead-sheathed steel bars.
(2) Bare steel bars, galvanised or bitumen-coated with zinc, lead or copper cappings.
(3) Aluminium alloy bars.
(4) Reinforced concrete bars with copper cappings.
(5) Timber bars with wood or metal cappings.

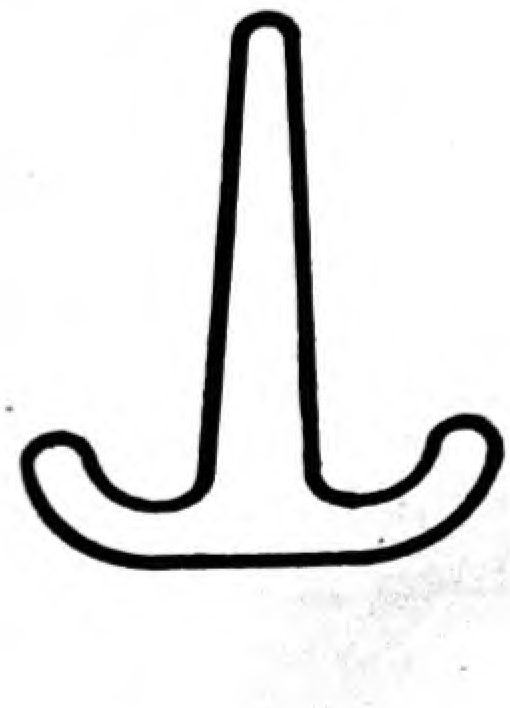
(1) *Lead-Sheathed Steel Bars.* This general classification comprises the large majority of patent glazing bars. The core, which is of mild steel, is generally protected from corrosion

before the lead sheath is applied. The reason for this is that lead offers only mechanical protection to the steel and not the electro chemical protection provided by, say, zinc. If the sheathing becomes punctured, the steel will corrode underneath, unless some additional protective coating is applied. On the other hand, lead itself is almost impervious to atmospheric corrosion, even in chemical works, and is perhaps the most suitable material for such positions. Its low mechanical strength prevents its use in solid form, and it is therefore applied to the steel core as a jointless lead sheath, or more rarely electrically deposited. The steel core may be galvanised, or coated with bituminous red lead or other anti-corrosive paint before the sheathing is applied.

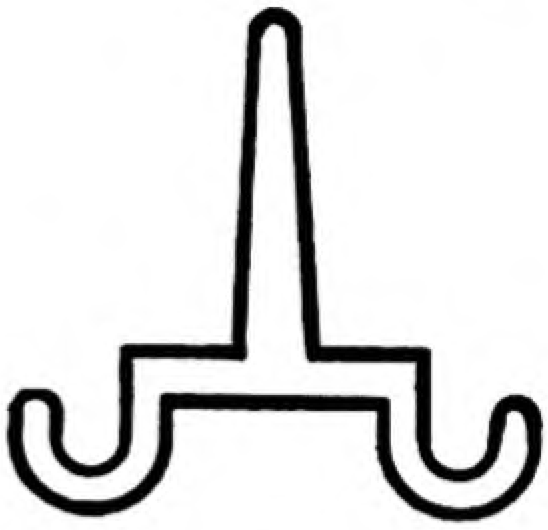
The sections vary in detail from one manufacturer to another, but in general provide a bearing surface for the glass consisting either of the lead sheath itself or asbestos cord and a single or double lead cover which is dressed down on top of the glass, and which may be flat, curved or corrugated in section. The two latter types have the advantage that they prevent capillary attraction between the cover and the glass. The bars vary from $1\frac{1}{8}$ in. to $2\frac{5}{8}$ in. in depth, according to span. The normal span is 7 ft. and the maximum in most types is 10 ft. 6 in., but in some sections spans up to 12 ft. can be used. They are generally spaced at 2 ft. centres.

The sections may be further classified under three distinct types:

(1) Inverted Tee, having drainage channel only.



(2) Inverted 'Y,' having condensation channel only.



(3) Combination of above, having both drainage and condensation channel.

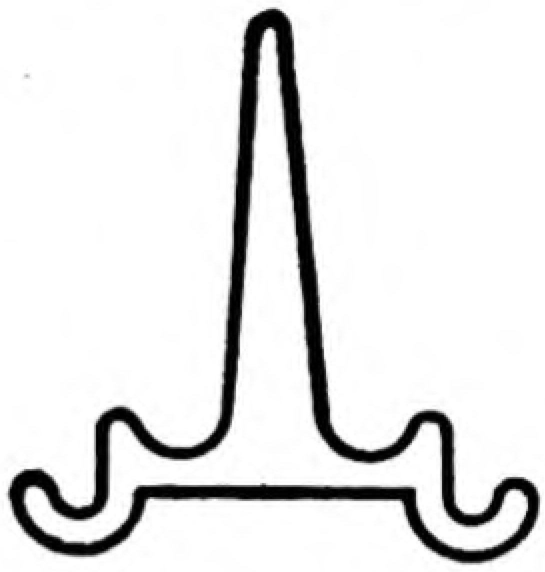
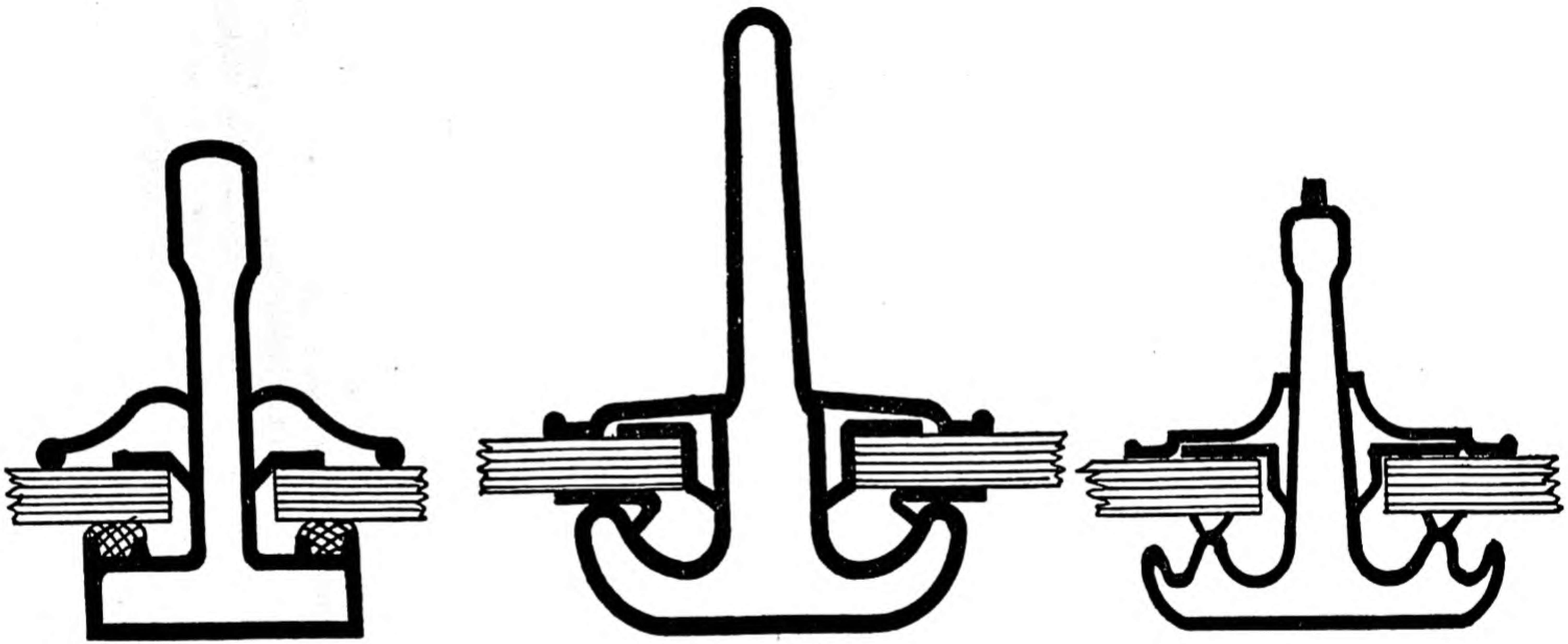


Fig. 9 shows typical examples of each of these types.

Another type is the 'Y' bar in which the rib is on the underside and therefore in tension. There are also combinations of the 'Y' and inverted 'T' in which part of the rib is in compression and part in tension.

Bars are fixed at the top by means of projecting wings already drilled for screws or bolts, and the hole bushed with lead tube to protect the steel core from corrosion. The bottom of the bar is held by a special shoe made of copper, gunmetal or bronze, which also supports the glass.

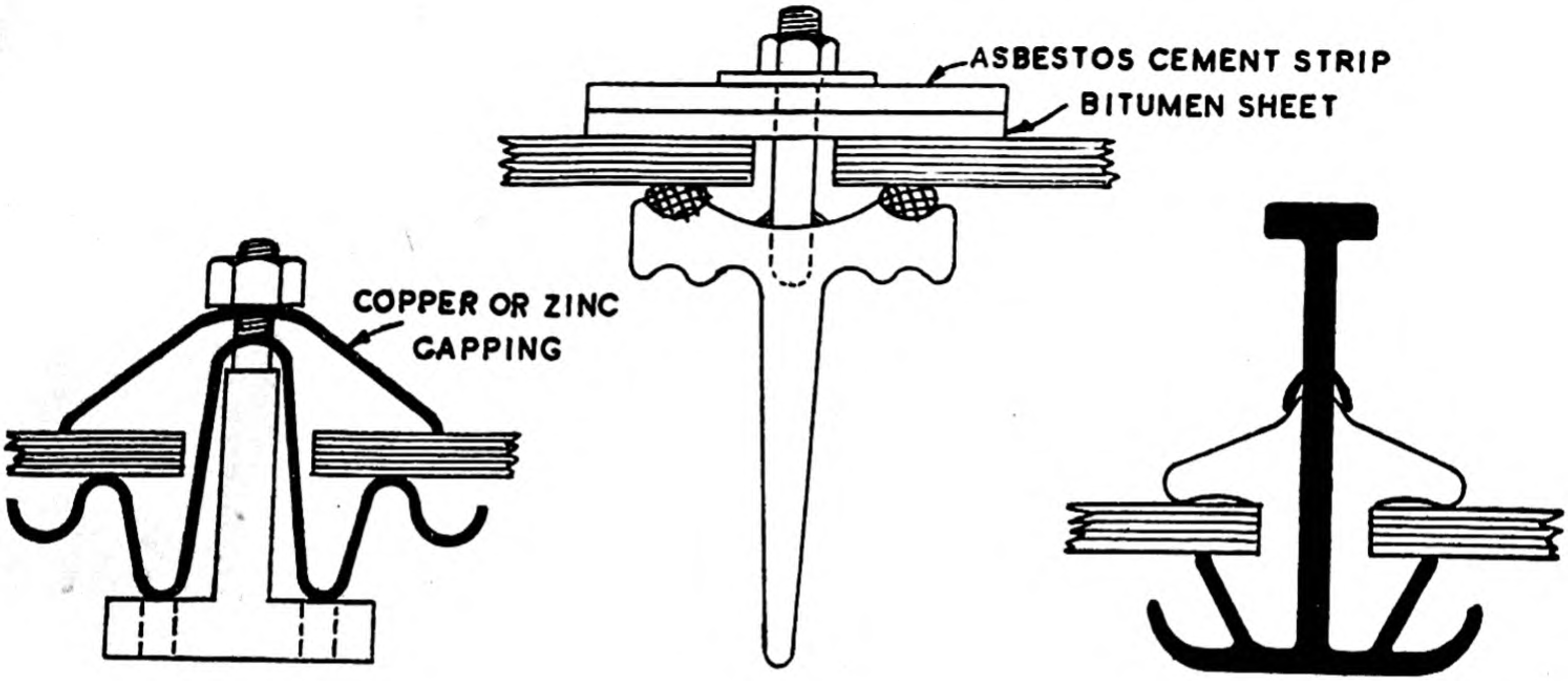
(2) *Bare Steel Bars.* A number of the sections already described are also available in galvanised or painted steel and partly sheathed in lead, or having separate cappings of lead, copper or zinc. Externally they have the same features as lead-sheathed bars, but are not so suitable for use in chemical or heavy engineering works, where the internal atmospheric conditions would considerably shorten the life of the zinc or painted coating. They are less expensive than lead-sheathed bars and, with zinc or copper cappings, are particularly suitable for use in the tropics, where the intense heat has a softening effect on lead.



HEYWOOD MELLOWES LUXFER

LEAD COVERED BARS

FIG. No. 9



BRABY HEYWOOD WILLIAMS

BARE STEEL BARS ALUMINIUM BAR

FIG. No. 10

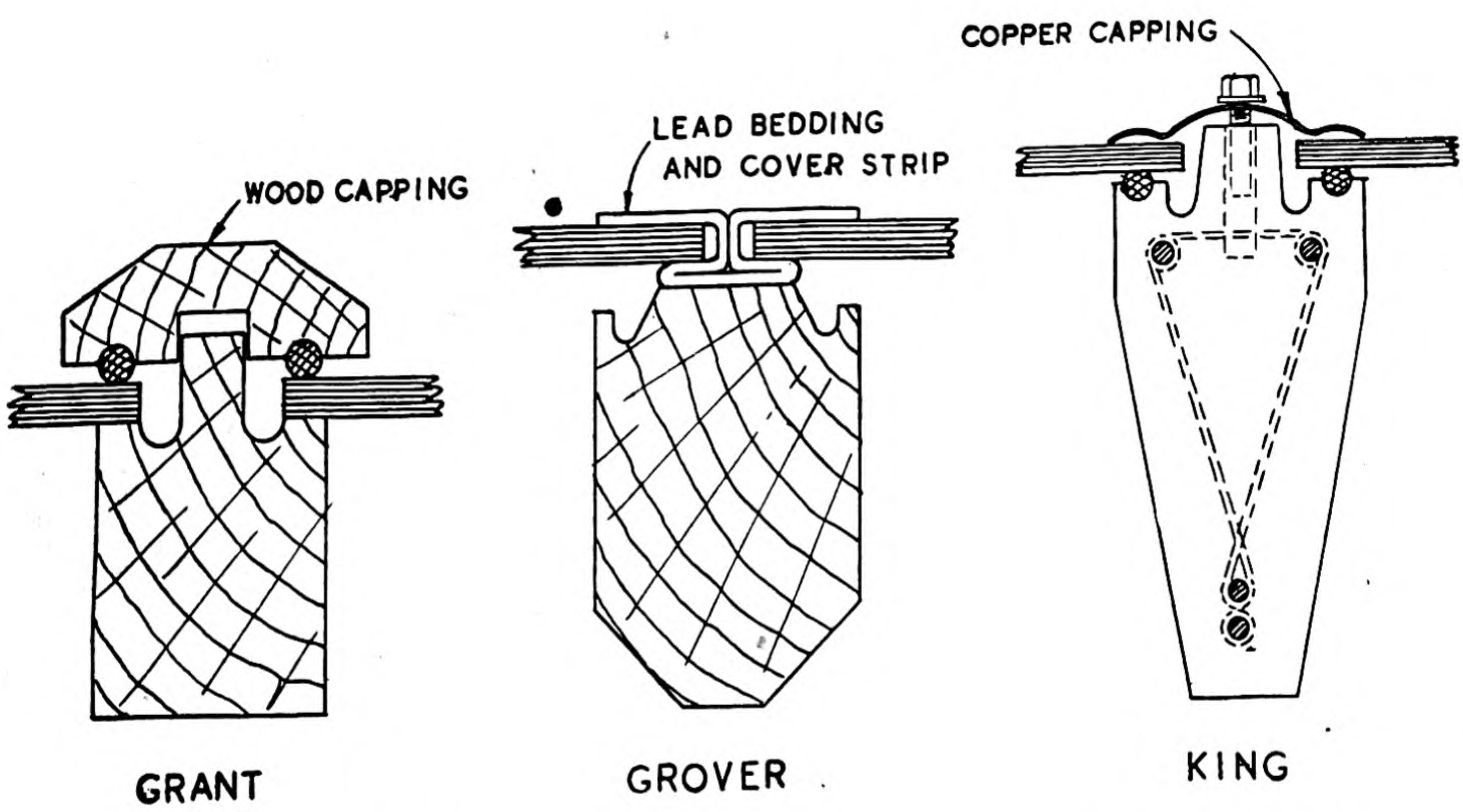
Normal and maximum spans, depths of section, and methods of fixing are the same as for lead-sheathed bars. Typical sections are shown in Fig. 10.

(3) *Aluminium Alloy Bars.* Although other non-ferrous alloys, such as bronze, have been used for patent glazing bars, aluminium alloy is more widely known. The advantages of this metal are lightness in weight combined with strength and rigidity and non-corrosive properties. There are two distinct types: one with lead cover, the other with aluminium alloy cover, which is sprung into position. The sections are $1\frac{1}{2}$ in. wide and range in depth from $1\frac{5}{16}$ in. to 3 in. for spans from 4 ft. 2 in. to 10 ft. 8 in. (See Fig. 10.)

(4) *Reinforced Concrete Bars.* This material, because of its fire resisting properties and resistance to chemical attack, is suitable for use in chemical works, engine sheds, foundries, gas works, etc. It has not, of course, the lightness in weight of metal sections and its larger bulk offers greater obstruction to daylight, but its special features warrant its consideration as a material for roof glazing bars, under some conditions.

A standard section is illustrated in Fig. 11. The glass rests on asbestos cord and is held in position by a copper capping, fixed to the top of the concrete bar by a bolt and washer screwed into a ferrule cast in the bar. It is made for spans up to 10 ft. spaced at 2 ft. centres.

(5) *Timber Bars.* Apart from reasons of economy, there are instances where timber bars are preferred to metal, such as in textile factories where it is desired to reduce condensation to a minimum. The inherent disadvantages of wood bars for putty glazing can be overcome by the use of special cappings of lead, copper, zinc or timber. Such bars are generally used with timber trusses and purlins, into which they are framed. Spans up to 11 ft. are obtainable, but, without a centre support, 7 to 8 ft. is normal. Typical sections are shown in Fig. 11.



TIMBER BARS

CONCRETE BAR

FIG. No. 11

CHAPTER VIII

GLASS AND CONCRETE CONSTRUCTION

Lenses—Glass Bricks—Pre-cast Concrete Window Construction

LENSES

Although the coefficient of thermal expansion of glass is considerably less than that of concrete, the combination of the two is made possible by the use of small suitably designed glass units to which the concrete will adhere, without the neecessity of bedding them in mastic.

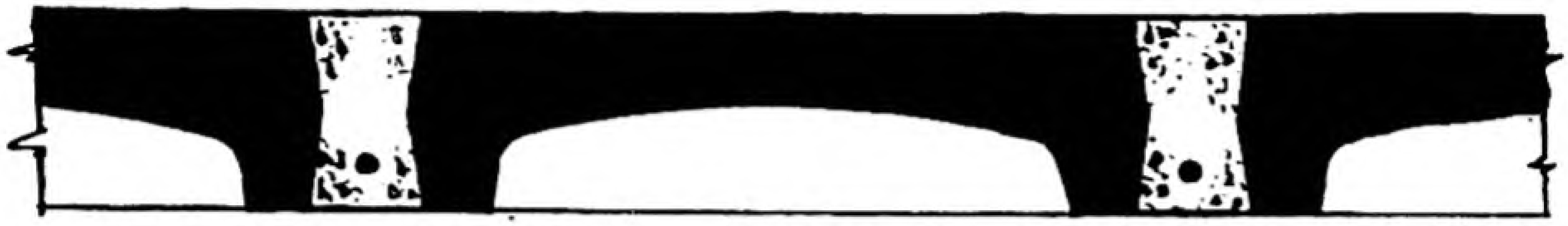
These units or lenses are manufactured by pressing, as already described in Chapter I. They are made in a wide variety of shapes, either square or circular in plan with the edges shaped to provide a key to the concrete. They may be of uniform thickness or dished on one face and generally have a patterned surface to give maximum light diffusion. Lenses may also be toughened in the same way as Plate Glass and are known under the trade name of 'Armourlight.' It is claimed that such lenses will withstand an impact approximately ten times as great as an ordinary tile of similar shape and twice the thickness.

Fig. 12 shows some typical examples of glass lenses.

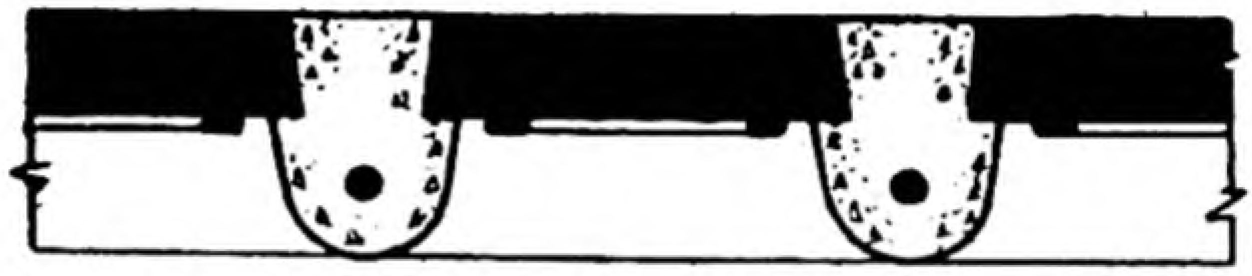
Fixing is generally carried out by specialist contractors, but it may be useful to mention a few of the basic principles in the design and construction of large glass-concrete structures, such as domed roofs, as distinct from small units, such as pavement and stallboard lights.

To allow for expansion and contraction with changes in temperature, expansion joints must be made at suitable intervals as in the case of ordinary reinforced concrete. The shuttering is first erected and the lenses placed in position.

LENSES 4 IN. UP TO 8 IN. SQUARE

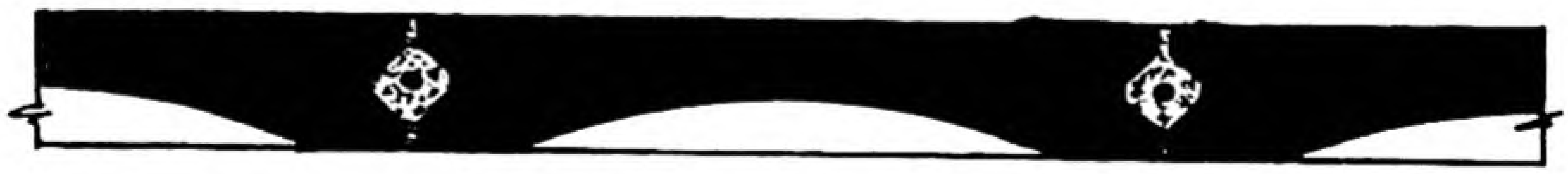


LENSES 4 IN. AND 8 IN. DIAMETER



LENSES 4 IN. AND 5 IN. SQUARE

LENSES 4 IN. 5 IN. AND 6 IN. SQUARE



SQUARE LENSES AT 8 IN. CENTRES

TYPICAL EXAMPLES OF GLASS LENSES

FIG. No. 12

Where hollow lenses are used this may be done by nailing plywood discs to the shuttering at the required centres and placing the lenses in position over them. The spacing of lenses and design of reinforcement is a specialist's job and no attempt is made to cover this aspect of the work in this book. A general principle is that the percentage bulk of glass should not exceed that of the concrete.

Suitably graded aggregate is used for the concrete and a 3 : 2 : 1 mix is common. This is grouted round the lenses to the height of the reinforcing rods, and the latter placed in position, care being taken to ensure that they are kept clear of the glass. The concreting is then completed, finishing level with the surface of the lenses. A few hours later the surface of the glass is cleaned with a wet cloth. Slow maturing of the concrete is necessary and it is advisable to keep it damp for at least four days.

GLASS BRICKS

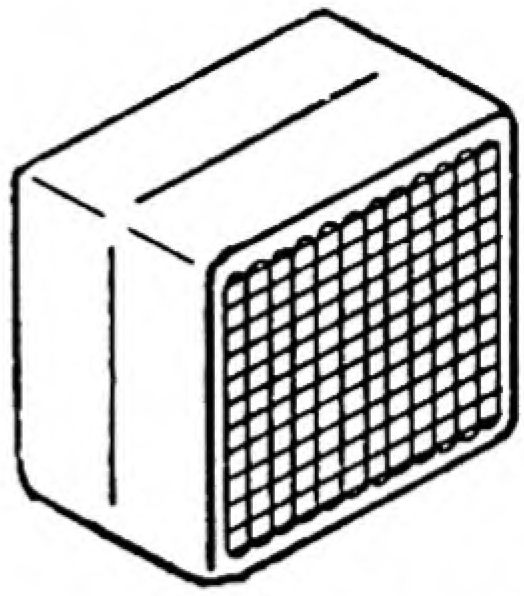
Some of the solid glass lenses already described might be described as glass bricks, but this term is generally applied only to hollow non-load-bearing units used mainly for walls.

The earlier types introduced to this country were made as single pressings and had one open side, generally the underside or bedding surface. They were laid with cement mortar in the same way as ordinary bricks, but were not hermetically sealed. Consequently, with atmospheric changes, the bricks were able to breathe and thus draw particles of dust into their interior, affecting very considerably their light transmission properties.

The modern glass brick overcomes this disadvantage, as it is made from two separate pressings, sealed together while hot, thus creating a partial vacuum inside on cooling. The edges are painted with a special paint and sanded in order to produce a surface to which mortar will adhere. These units, known as 'Insulight Hollow Glass Blocks,' are made in the following shapes and sizes:

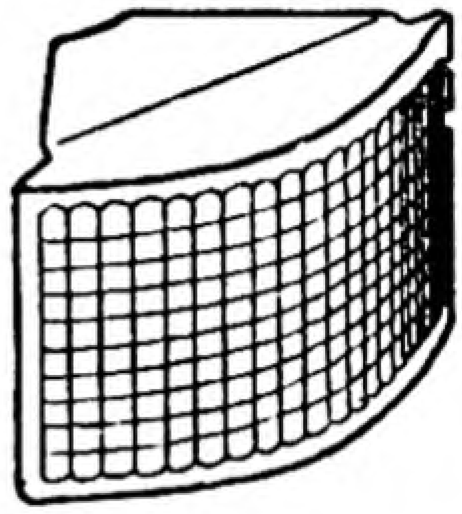
(*a*) P.B.2

$5\frac{3}{4}$ in. by $5\frac{3}{4}$ in. by $3\frac{7}{8}$ in. Surface pattern of $\frac{1}{2}$ in. convex ribs carried vertically on both exterior faces and horizontally on both interior faces. Approximate weight 3 lbs. 11 ozs.



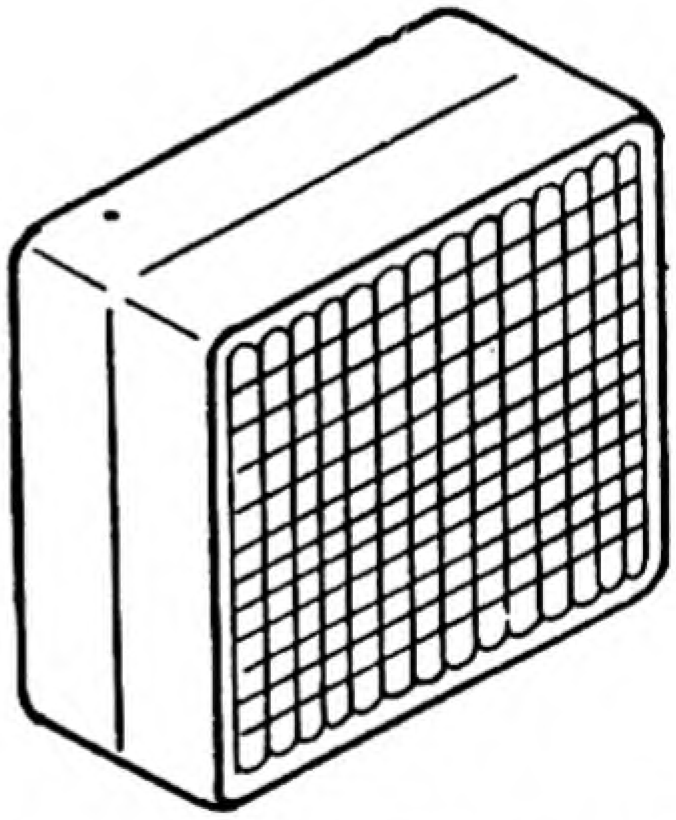
(*b*) P.B.2. Corner Brick

Surface pattern of $\frac{1}{2}$ in. convex ribs carried vertically on both exterior faces and horizontally on both interior faces. Approximate weight 3 lbs. 10 ozs.



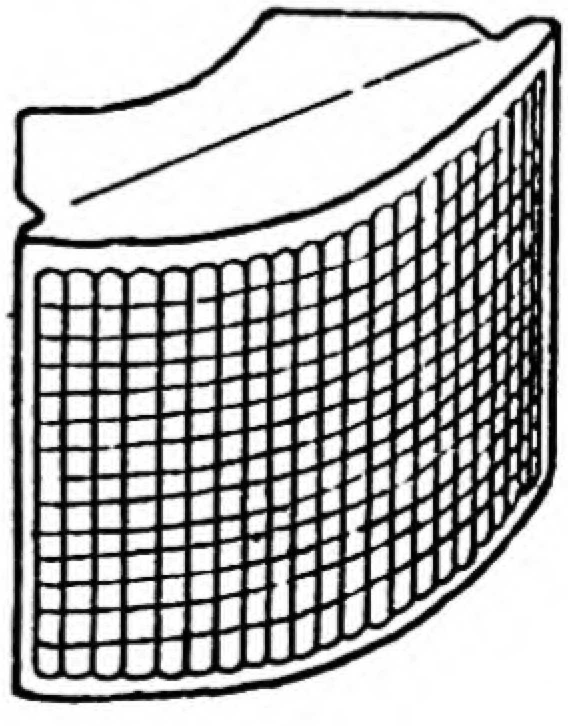
(*c*) P.B.3.2

$7\frac{3}{4}$ in. by $7\frac{3}{4}$ in. by $3\frac{7}{8}$ in. Surface pattern of convex ribs carried vertically on both exterior faces and horizontally on both interior faces. Approximate weight 6 lbs.

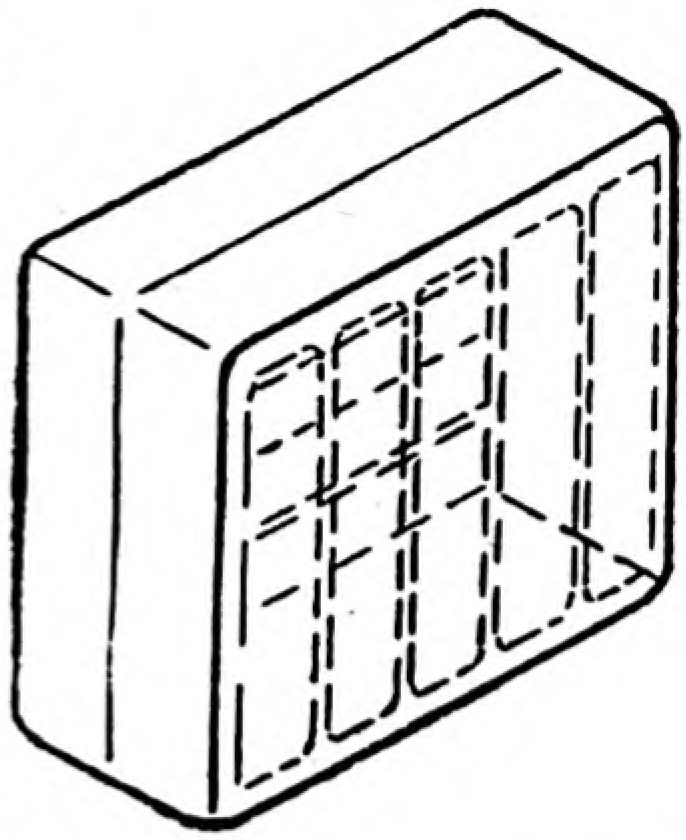


(*d*) P.B.3.2. Corner Brick

Surface pattern of $\frac{1}{2}$ in. convex ribs carried vertically on both exterior faces and horizontally on both interior faces. Approximate weight 7 lbs. 10 ozs.

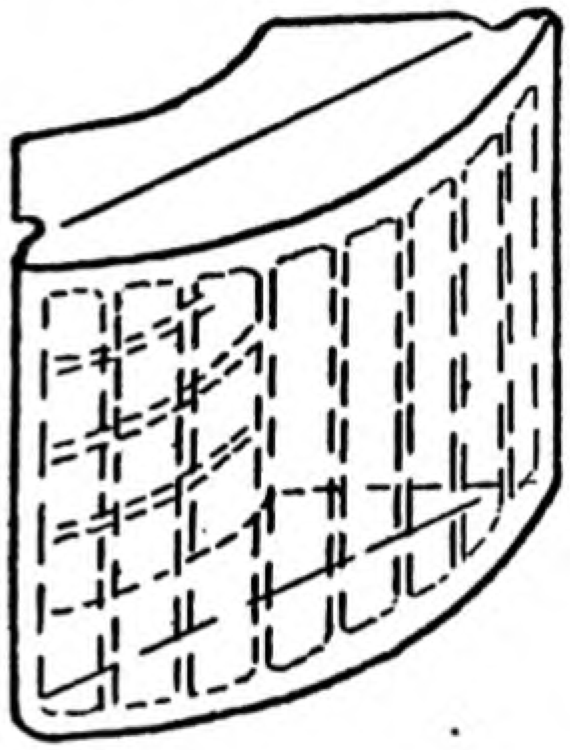


(*e*) **P.B.3**



$7\frac{3}{4}$ in. by $7\frac{3}{4}$ in. by $3\frac{7}{8}$ in. Surface pattern of $1\frac{1}{4}$ in. concave ribs carried on both interior faces, running vertically on one face and horizontally on the other. Both exterior faces are smooth. Approximate weight 6 lbs.

(*f*) **P.B.3.** Corner Brick



Surface pattern of $1\frac{1}{4}$ in. concave ribs carried on both interior faces, running vertically on one face and horizontally on the other. Both exterior faces are smooth. Approximate weight 7 lbs. 10 ozs.

They are non-load-bearing units which will carry their own weight with a wide safety factor up to any practical height, but because of wind pressure and other stresses it is necessary to put in an intermediate support in panels over 20 ft. high or 120 ft. super. Very wide panels require an expansion joint every 20 ft.

The following recommendations for fixing are made by the manufacturers:

Mortar. A fairly dry and fatty mortar is advisable, as the glass bricks are non-absorbent. The best mix has been found to be 4 parts (by volume) sand, 1 part Portland cement and 1 part slaked lime putty, mixed fairly dry. Clean builders' sand free from gravel (not sea sand) should be used.

Pointing. The face of the joints may be struck back and smoothed during erection, or they may be raked out and

later pointed up with Snowcrete, colourcrete or similar materials. A 'keyed' joint formed with a curved jointing tool is the finish mostly used.

Reinforcement. Reinforcing strips should be built into every third to every fifth course according to the size and position of the panel. The ends should pass through the clearance joint and be built into or secured to the main structure. 'Exmet' 2½ in. wide No. 20 gauge expanded metal has been found suitable for this purpose.

Clearance Joints. The head and both vertical sides of every panel must be built into recesses free of the main substructure—except for the reinforcement—to avoid risk of settlement load or expansion strains affecting the panel. The recesses, which should be kept free of any spillings of mortar and filled with a non-hardening compound of which there are many suitable varieties on the market, should be 4¼ in. wide by 1 in. deep, allowing a ½ in. clearance and a ½ in. cover over the face of the glass brick, with $\frac{3}{16}$ in. play on either face.

Sills. The bottom course should be bedded in cement mortar on to the sill, which should first be coated with an asphalt emulsion to allow for slight movement without disrupting the mortar bed and thereby preserving the weather-tightness of the panel.

Doorways. Doorways which have to be built into a panel need special structure details to avoid shock and strains being transmitted into the panel.

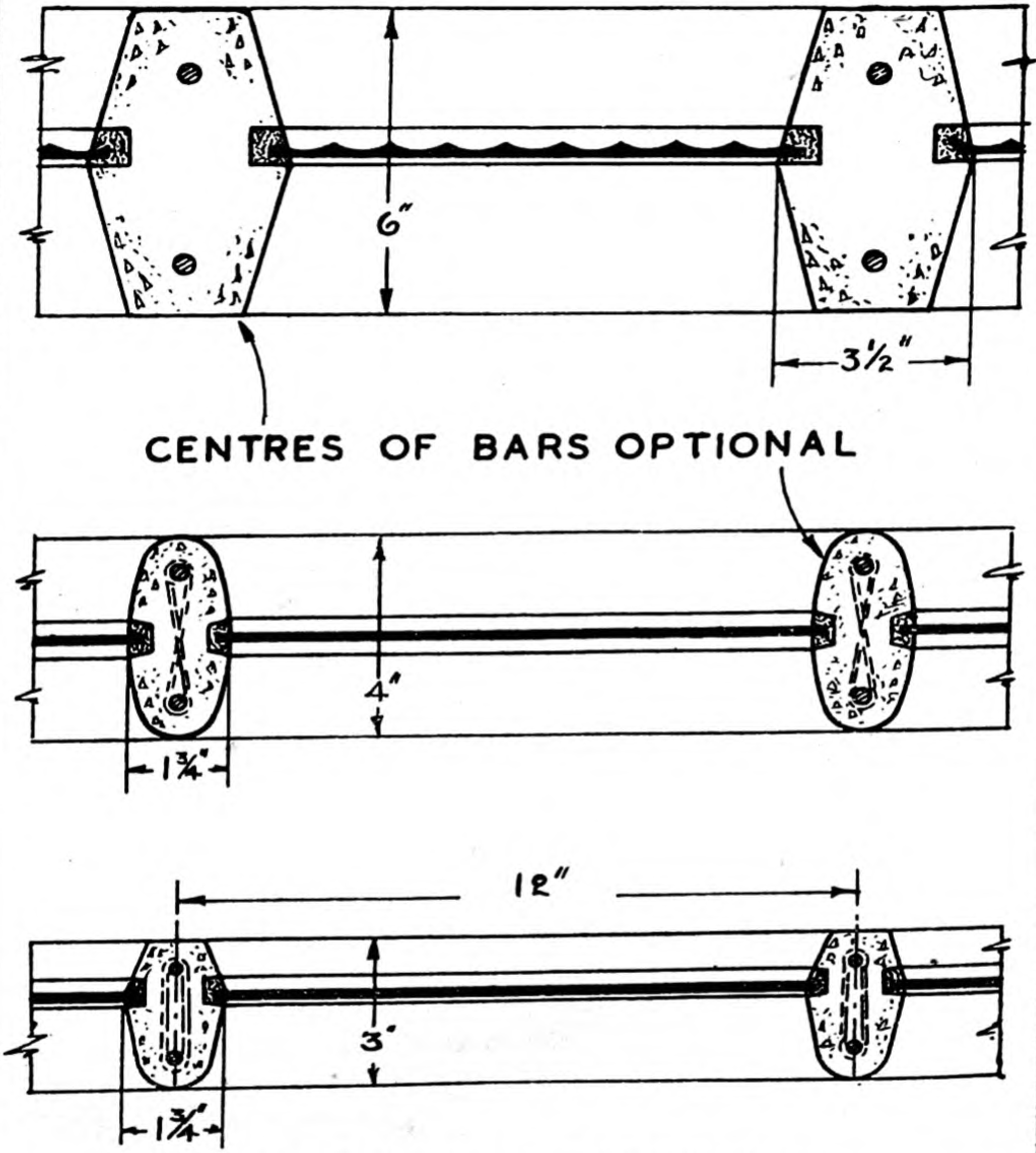
Tests on Insulight Hollow Blocks have been carried out by the Building Research Station to determine the following properties:

Light Transmission. No. 538. Ref. BRS. 36/12/16B.

Transmission of Airborne Sound. No. 451. Ref. BRS. 36/12/16.

Compressive Strengths. No. 480. Ref. BRS. 36/12/16.

Transmission of Heat. No. 569. Ref. BRS. 36/12/16B.



PRECAST CONCRETE
VERTICAL GLAZING BARS

FIG. No. 13

They have also been tested for fire resistance and classified Grade D under British Standard Definitions No. 476 as a fire-resisting building material. Copies of reports on all of the above tests are available from the makers.

The combination of these properties makes Insulight Glass Bricks an eminently suitable material for external and internal walls, where the maximum amount of light transmission combined with diffusion and high thermal efficiency is required.

They may be used on flat or curved surfaces and are also used for staircase lights, shop stall risers, door surrounds, bar counters and cinema foyers (generally with artificial lighting effects). Their sound insulating properties make them highly suitable for internal partitions.

PRE-CAST CONCRETE WINDOW CONSTRUCTION

Concrete roof glazing bars have already been referred to in Chapter VII. In addition there are a number of pre-cast sections available, suitable for vertical walling. These may be in lengths up to 14 ft. maximum, or in pre-cast panels up to 8 ft. by 8 ft., having square or rectangular openings. Some typical details are shown in Fig. 13.

CHAPTER IX

PHYSICAL AND MECHANICAL PROPERTIES OF GLASS

Weight—Strength—Thermal Conductivity—Solar Radiation—Sound Transmission—Light Transmission and Diffusion

Weight

The average weight of structural glass is 160 lbs. per cubic foot. This information is of little value to the designer, as the latter is chiefly concerned with the weight per square foot of the different types of glass. These weights are given throughout the book under the descriptions of these glasses.

Strength

The principal stress imposed on glass windows is wind pressure. This is a variable factor, but it is customary to design the window to withstand the maximum pressure likely to be exerted. This will vary according to exposure, and to conform with the L.C.C. Building Regulations (1930) for the upper two-thirds of a building should be 15 lbs. per square foot, corresponding to a 68.5 mile per hour wind velocity. This value will not apply to shop fronts unless these are in an unusually exposed position.

For windows at ground level in an ordinary town environment, calculations may be based on a maximum wind pressure of 6 lbs. per square foot (42 m.p.h. wind velocity).

This load will be uniformly distributed and the window pane should be considered as a flat plate, freely supported on all four edges. It therefore follows that a rectangular pane will withstand a greater stress than a square pane of the same area.

The calculation, on a scientific basis, of the maximum sizes of sheet and plate glass to withstand given wind

pressures is complicated by the fact that the tensile strength of glass is an extremely variable factor.

If a number of similar specimens are made and tested at a particular stress, the percentage that break gives the percentage risk. It is generally considered safe to take a 1% risk as a basis, since in making calculations the loading factor is assumed to be the worst that can occur.

The following are the permissible tensile stresses for the principal types of glass determined on the above basis:

Plate	3.600 lbs. per square in.
Sheet	5.350 ,, ,, ,, ,,
Rolled	2.675 ,, ,, ,, ,,
Wired	2.000 ,, ,, ,, ,,

Curves showing the safe glazing sizes for sheet and plate glass are shown in Figs. 1, 2 and 3.

THERMAL CONDUCTIVITY

The variation in thermal conductivity of the various types of glass used for glazing is almost negligible, and this value may be taken at an average of 8.B.Th.U./square foot/degree Fahrenheit/inch.

When this figure is compared with that of insulating materials, such as Glass Silk (0.28) or cork (0.29-0.43), it will be seen that variations in thickness within the limits used in glazing, have little effect on the overall transmission of heat by conduction.

Other factors, such as surface resistance, must also be taken into account. This is illustrated by the fact that although glass has almost the same thermal conductivity as brickwork, the heat loss through a ¼ in. plate glass window is little more than three times that through a 13½ in. brick wall.

The surface resistance of glass varies according to exposure. Typical values are:

Surface resistance (external) for gale conditions	0.0
Average for external winter conditions . .	0.2
Surface resistance (internal) in still air . .	0.7

The total air to air transmission coefficient for single glazing is the reciprocal of the sum of the resistances.

These are:	Internal surface resistance . .		0.7
	Resistance of $\frac{1}{4}$ in. glass	$\frac{\frac{1}{4}\text{ in.}}{8} =$	0.032
	External surface resistance . .		0.2
			0.932

Overall air to air transmission coefficient =

$$\frac{1}{0.932} = 1.08 \text{ (B.Th.U./square ft./hr./1°F.).}$$

The effect of double glazing is not merely to increase the thickness of the glass, but to provide the additional insulation of an enclosed air space.

The thermal resistance of an enclosed air space varies with width up to a maximum of about $\frac{3}{4}$ in., after which there is no appreciable increase in resistance.

For a $\frac{3}{4}$ in. air space the resistance has been determined by experiment as .90 B.Th.U./sq. ft./ °F.

Thus the total thermal resistance of a double glazed window of $\frac{1}{4}$ in. glass with $\frac{3}{4}$ in. air space is:

Internal surface resistance . . .	0.7
$\frac{1}{4}$ in. plate glass	0.032
$\frac{3}{4}$ in. air space	0.9
$\frac{1}{4}$ in. plate glass	0.032
External surface resistance . . .	0.2
	1.864

Overall air to air transmission coefficient =

$$\frac{1}{1.864} = 0.54 \text{ B.Th.U./sq. ft./hr./1°F.}$$

which is roughly the same as for 6 in. ballast concrete.

Double glazing for heat insulation has not been used to

the same extent in this country as on the Continent and in America, because we have not the same extremes of atmospheric temperature. There is, however, a strong case for its use in windows facing north as an alternative to reducing the size, with consequent loss of illumination, particularly in studios, operating theatres, etc., where adequate north lighting is desirable.

SOLAR RADIATION

A factor which is usually neglected when computing the heat loss from a building is the contribution to the ordinary central heating system which is made by the transmission of solar heat through glass. The most obvious reason for this is the difficulty in estimating the hours of probable sunshine during the autumn and winter months, but such figures can be compiled from the Meteorological Office Weather Records.

It has been shown* by comparing the solar heat transmitted through a large window (100 square feet effective area), and the amount by which the central heating system is supplemented, with similar figures for a small window (25 square feet effective area) that for a south aspect the former shows a saving of from 14% to 25%, according to locality, on the heating cost, as against 4% to 12% for the smaller window.

Of the total solar heat striking a pane of glass, an amount 'T' is transmitted directly into the room, an amount 'R' is reflected, and an amount 'A' is absorbed and dissipated by convection and re-radiation.

It should be noted that glass is almost impervious to low temperature radiation, and no heat is allowed to escape from the inside of a room, other than by conduction.

The main problem of solar radiation is to exclude the heat of the sun in summer, and it is for this reason that special glasses such as Calorex and Non-Actinic Glass have been produced. The values of 'T,' 'A' and 'R' for ordinary and

* 'Glass as a Structural Material,' J. R. I. Hepburn.

heat absorbing glass are given in the following table:

	T.	*A.*	*R.*
Ordinary glass . .	0.80	0.12	0.08
Heat absorbing glass .	0.20	0.75	0.05

Sound Transmission

The insulation provided by a structural unit, such as a partition or window, against the passage of airborne sound is measured in Noise Units, or Decibels.

The average sound insulation for typical single and double glazed windows is given in the following table:

Type of Window	*Noise Units*
Single 21 oz. glass	25
Double 21 oz. glass 1 in. apart . .	35
Double 21 oz. glass 6 in. apart . .	45
Single ¼ in. plate glass . . .	30
Double ¼ in. plate glass 6 in. apart .	55

The advantage of double glazing is clearly apparent, and by careful insulation between the panes, and the lining of the reveals with an acoustically absorbent material, the sound insulation of a double ¼ in. plate glass window may be increased to 65 Noise Units.

It will also be noted that it is advantageous to increase the width of air-space beyond 1 in., differing in this respect from the results of tests on the heat transmission through air spaces. It has also been suggested that in order to alter the period of vibration of each pane, the inner pane should be of different size or different thickness to the outer.

Double glazing is used mainly in office buildings, hotels, etc., for rooms overlooking busy thoroughfares. Several types of double frames are made by the manufacturers of metal windows, in which special provision is made for cleaning the inner surfaces of the glass.

LIGHT TRANSMISSION AND DIFFUSION

When a ray of light strikes a glass sheet it is partially reflected, partially absorbed and partially transmitted. For clear sheet glass, about 8% of the incident light is reflected, 2% absorbed and 90% transmitted. In the case of figure rolled glasses about 12% is reflected, 3% absorbed and 85% transmitted. This amount is transmitted in random directions and gives what is termed a diffused light.

The amount of diffusion will vary according to the pattern and surface texture of the glass, and as this amount increases, the percentage transmission will be lowered. In the case of opal glass only 55% of the incident light is transmitted through the glass, but this is fully diffused. Nevertheless, it is possible that a window glazed with opal glass, having a transmission factor of 55%, will give better illumination to a room than if glazed with clear sheet glass, having a transmission factor of 90%.

Light diffusion is necessary inside a room in order to prevent harsh shadows. It may be provided by the use of special diffusing glass, by having several sources of light, or by making use of the reflection factor of wall decorations. When choosing patterned or obscure glasses it is therefore necessary to consider the diffusion factor as well as the transmission factor.

Wire reinforcement reduces the percentage light transmission through glass. 'Georgian' wired patterned glasses have a light transmission of 75% to 80%, and hexagonal mesh wired patterned glasses from 70% to 75%.

Coloured glasses have a lower percentage light transmission than clear glass.

The following table gives the approximate percentage light transmission for each of the 67 standard tints of Cathedral Glass and (marked with an *) the 13 standard tints of Figured Rolled Glasses.

Grade No.	1	2	3	4	5	6
Name	Approximate percentage transmission for daylight					
Violet	80	65	50	20	—	—
Cobalt	80	*70	*40	3	1	—
Marine	80	60	35	25	5	—
Turquoise	80	75	65	45	30	—
Emerald	80	70	55	35	20	—
Green	75	*60	*50	*35	20	—
Foliage	70	60	50	40	12	—
Sage	*75	55	40	30	6	—
Olive	75	65	40	30	25	—
Yellow	80	*70	*60	*50	*40	35
Russet	*75	*70	65	60	55	40
Pink	70	65	*35	25	10	2
Amethyst	80	60	50	20	5	—

INDEX